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Return of the Jedi 15

With the patience of a Jedi master, writer-director George Lucas waited sixteen years before determining the time was right to launch his much-anticipated *Star Wars* prequel, *The Phantom Menace*. Stepping back into the limelight to personally shepherd the project through its four-year production odyssey, the visionary filmmaker shares his insights on the most ambitious effects movie ever made. *Interview by Don Shay.*

Phantom Visions 39

An enormous conceptualization effort, headed by design director Doug Chiang, lent form and substance to Lucas' imaginings of *The Phantom Menace*'s fantasy worlds. Initially comprised of just Chiang and another illustrator, the team eventually expanded to include seventeen artists, pumping out endless sketches, paintings, sculptures and models in the Skywalker Ranch art department. *Article by Mark Cotta Vaz.*

Heroes' Journey 74

Fittingly, it was Industrial Light & Magic, the much-honored company established by Lucas to produce the revolutionary effects in *Star Wars*, that would undertake the staggering task of bringing his latest opus to fruition. For *The Phantom Menace*, ILM would pull out all the stops, calling upon both veterans of the earlier trilogy and a newer generation of digital devotees to advance the art of visual effects to dizzying heights. *Article by Jody Duncan, Kevin H. Martin and Mark Cotta Vaz.*

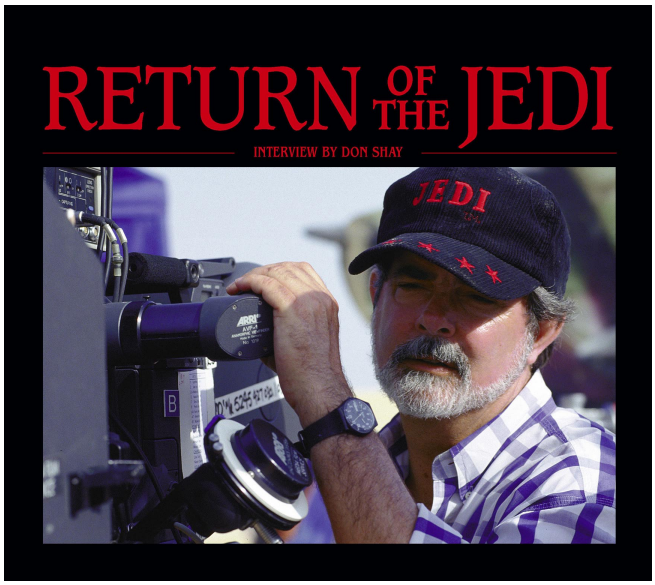
Populating Planets 149

Although computer animation would play the more prominent role in populating *The Phantom Menace*'s alien worlds, hundreds of whimsical characters—both background and principal—were constructed for on-set use by creature creator Nick Dudman and his crew of animatronics and makeup specialists. *Article by Estelle Shay.*

COVER—Jar Jar makes a silent pronouncement in *The Phantom Menace*.

RETURN OF THE JEDI

ARTICLE BY DON SHAY



The screening room at Industrial Light & Magic is larger than many neighborhood multiplexes – and far more opulently appointed, with state-of-the-art projection and sound, and seating designed with evident attention to both comfort and line of sight. There was a time, not that long ago, when the room was large enough to seat the entire ILM workforce for a traditional once-a-month social gathering in which all of the footage completed during the month was shown so that individuals laboring on different projects could be kept abreast of the company's collective achievements. No more. The monthly ritual still stands, but four back-to-back showings are now needed to accommodate the 1200 artists and technicians presently creating magic at the world's most celebrated visual effects facility.

To the left of the screen – just above R2-D2, who has evidently staked out a permanent front-row seat – is a decorative plaque on which the most prestigious of ILM's many honors, its fourteen Academy Awards, are proudly enumerated. It has been four years since the last entry – an unprecedented lapse in the company's twenty-plus-year history – but there is a sense in the room to day that that is destined to change, for the project on which those currently assembled are working is Star Wars Episode I: The Phantom Menace, the most ambitious and eagerly awaited effects film of all time.

It is early March, and roughly two months remain to final the two hundred or so effects shots needed to complete the massive production. Two hundred shots would normally be considered a prodigious workload for a major effects film – in its entirety – but in this instance, it represents only a tenth of the total output for this revolution ary enterprise. For more than a year, an army of artists has been churning out an average of thirty-five shots a week in order to meet the picture's May 1999 release date. And as a testament to its mastery of both the artistry and logistics of visual effects, ILM has also been juggling two other big projects, Wild Wild West and The Mummy, at the same time.

Twice a week, George Lucas departs his rural headquarters at Skywalker Ranch, where he continues to fine-tune the movie while at the same time running his fistful of companies and writing the next Star Wars screenplay, and drives about twenty minutes to the sprawling ILM

enclave in San Rafael to attend dailies and give notes on the work in progress. Wielding a hand-held laser pointer like a makeshift lightsaber, he sits for an hour amongst his visual effects supervisors and other key players, absorbing every detail on the screen and offering quiet observations and suggestions for changes and improvements.

Fragments of scenes flash past in a kaleidoscope of imagery so dense that multiple viewings – the prime ingredient of boxoffice megahitdom – will surely be in order for anyone intent upon absorbing all the layered nuances. Under scrutiny are shots of Jedi master Qui-Gon Jinn and apprentice Obi-wan Kenobi wending their way through the dusty alien-populated streets of Mos Espa, of young Anakin Skywalker at the controls of his souped-up podracer, of klutzy Gungan sidekick Jar Jar Binks accidentally unleashing a wagon load of bouncing energy balls, of menacing water monsters and vast battle droid armies, of donut-shaped Trade Federation battleships and the wondrous cities of Theed and Coruscant – images of scope and beauty and action a generation of fans have been craving since the last new Star Wars film was released sixteen years ago, and which, until only recently, had been locked away in the mind of George Lucas awaiting advances in imaging technology sufficient enough to make possible the realization of his expanding vision.

The creator of all this seems pleased, both with what he sees on the screen and with the greater realization that his four-year filmmaking odyssey is nearly at an end – if only for a short while before commencement of the next...

The scope of this film is enormous – like a David Lean movie.

Because of the digital technology, I was able to think about a much grander, more epic scale - which is what I wanted Star Wars to be. Most people thought of Star Wars as being epic and grand, but it wasn't - it was just an illusion. I didn't have very many resources to do the kinds of things I wanted to do back then, even though I was able to successfully give the impression that that was what I had done. But with this one, I have actually been able to - in a much more concrete way - make it be on a large scale. With the economics of film today, doing large-scale motion pictures is something that's pretty much not available to most filmmakers. You can spend money on action set pieces and you can spend money on stars; but if you want to do a sweeping period piece, it's very difficult - because everyone says that historical dramas don't do well. So you have to do a little tiny thing, a Merchant Ivory kind of film; you can't really do something big, like Ben-Hur, because not enough people will go see the movie, and it costs too much. But with digital technology, all of that opens up again. Suddenly a lot of filmmakers can think of stories that are period pieces, that are fantasy pieces. With digital technology now an option that's available to them, they're not just stuck in this very narrow, creative alley of doing particular kinds of action pictures or contemporary dramas.

Over the years, under frequent interrogation, you've stated that one of your main reasons for the long delay after the first three Star Wars films was that the technology wasn't in place for you to do them the way you wanted – to tell the stories you wanted to tell. At what point did you decide that it was – and why?

When we did Jurassic Park, which started out to be stop-motion. The moment we found we were able to do the dinosaurs digitally, I realized that we had reached the level we needed for me to

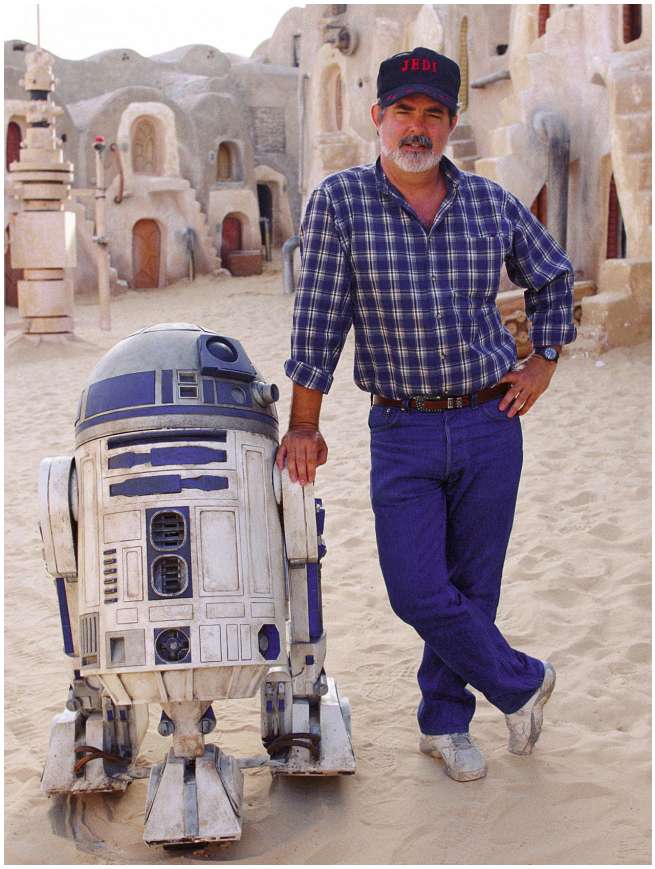
start thinking about Star Wars again. That was really the determining factor on the technical side. I had been working on the Young Indiana Jones series, and on that had been toying with a lot of ideas about how to create and utilize virtual backlots, manipulate images and advance nonlinear editing to the point where I could reconfigure the process. With Jurassic Park in the mix, and seeing a completely digital character that was one-hundred-percent believable, I thought, “Well, as soon as I finish this Young Indy thing and get it out of the way, my next project will be to get back into Star Wars again.”

The original Star Wars introduced some major advances in visual effects. But when you consider the technology available then, and compare it to the technology available now – only twenty-three or twenty-four years later – the difference in capability is mind-boggling. Did you have any idea that the technology would have progressed that far that fast?

Well, I was always hoping it would, so I guess I did conceive of it. I was pushing it as hard as I could and doing everything I could to make it happen, because I desperately wanted to be able to make movies in a more facile way, with more freedom than I’d had in the past, and I was frustrated with a lot of the hurdles that had to be overcome to do the simplest things using the old systems. So to me it was like living in the silent era, and suddenly now having sound to deal with.

I compare it to the advancement of art - when artists moved from doing frescoes, where they had to put plaster on a wall and then get their picture painted on it before it dried, to the invention of oils and canvas where they could take the canvas anywhere they wanted and no longer be limited to the wall of the building they were working on. They could actually paint a landscape and be out there in the woods. Plus there was time to do it, because oils took long to dry. So they could paint and paint, and then paint over it. That was a major technological revolution for the artist - and I think digital technology is on that level.

In the past, filmmakers were pretty much lim ited to what they could get in principal photog raphy. The images were essentially locked, aside from whatever visual effects might be added, and the shots were pieced together in a fairly linear manner. Based on what you've achieved with the new Star Wars, where you've created totally syn thetic characters and environments throughout, this is apparently no longer the case.



On location in Tunisia, George Lucas poses with R2-D2 on the Mos Espa street set built for Star Wars Episode I: The Phantom Menace, the long-awaited prequel to his epic space saga.

The technology is very powerful - much more than one might expect. Your talent and your craft in terms of what you do in telling the story is the same; but instead of working on a dark wall with a candle and having to paint in a very structured en vironment that is difficult to work in, you suddenly can go out, you can see the world differently, you can paint it in a different kind of way. You're freer. And that's a very important thing for the creative artist. Instead of working under very difficult con di tions, you now are able to go out and manipulate things that you couldn't before. Until recently, film making was an assembly-line process. You wrote the script - that was the blueprint - then you went out and you shot it. You filmed a bunch of images, and then you took those images and strung them along one after the other. That was about as much as you could do - and you were limited by that. Now you're not, because now you can work within the image. The image is no longer fixed on the film. Obviously the process of visual effects - certainly from the beginning of ILM - was to 'unfix' those images. The whole idea of taking images and put ting them into an optical printer and manipulating them, even though we were doing it mechanically and it was very difficult with photochemical proc esses and the like, we were still beginning to have the freedom to move those images around ever so slightly. But now, digitally, between nonlinear edit ing and just having the images in a digital world to work with, everything is possible - it changes the face of the filmmaking process.

There’s a big to-do about that in still photog raphy. When a nature photographer like Art Wolfe goes and digitally alters some of his images for one effect or another, many in the photographic community consider that cheating. Is there some thing comparable to that within the filmmaking community? Do filmmakers tied to the old ways consider this cheating?

Taking the directorial reins for the first time in more than twenty years, Lucas works with actor Jake Lloyd in preparation for a scene in which Anakin Skywalker, a young slave, enters a high-stakes podrace that will earn him freedom and set him on a course toward his dark destiny.

It’s not the same. Originally, photography was supposed to be documentary - it was supposed to capture reality - and some people could capture that better than others. Then, as photography got more artistic, people began to appreciate it in terms of the image itself. As it got even more artistic, it came to be like painting or like fine art - it didn’t have to duplicate reality. But to say that a photog rapher can’t manipulate his image is ridiculous - photographers do that all the time, ultimately. They use different f-stops; they put the film in the bath for different lengths of time; they do all kinds of tricks. Is Man Ray not a photographer because he manipulated his images? Of course not. It’s a bogus argument. But that thinking comes out of the fact that photography was supposed to represent the truth - it was supposed to be factual. But not any more. Photography is an art, just like any other.

Theatrical motion pictures have never been in that ‘factual’ category. You have news footage, you have documentary footage - which are supposedly realistic images - and then you have movies, which are completely fantasy images. There’s nothing in a movie that’s true or real - ever. When I did the Star Wars special editions, people would say: “You’re dealing with all this digital technology, and now you can use this stuff and cheat and do all kinds of things. Don’t you feel you’re compromising the integ rity of the film?” And I’d say: “Wait. I hate to disillusion you, but the people in the movie are actors playing parts. The characters are not real. The sets are not real. If you go behind that door you’ll see there’s no building - it’s just a big flat piece of wood. Nothing is real. Not one little tiny minutia of detail is real.” Some people find it hard to get behind that fact - but there it is. With this digital technology, all we’ve created is a new tool to help facilitate that illusion of reality.

Do you feel this approach to filmmaking is accessible to filmmakers who are not as techno logically oriented as you are?

First, I’m not all that technologically oriented. The advantage I have is that I went to film school. I started out as an animator and a photographer, and then I became an editor. Later on, Francis Coppola turned me into a writer and a director of actors. Those are all aspects of the process. To be a film director, you really need to know all of the things that go into making a movie. It’s very hard to com municate with people in the various departments if you don’t know what they do and how they do it and what the issues are. Directing films is a very multifaceted

discipline. You have to know music, you have to know literature, you have to know art, you have to know computer technology. I don't know a lot about computer technology, but I know enough to get myself around. I don't know a huge amount about special effects, either, but I know enough to get myself around. I know enough so that when I'm talking to somebody who is a gifted artist in one of these fields, I can communicate with him enough to get what I want. I think if you don't know about these things, or you don't know enough, it would be very difficult to communicate with people and get what you want. So in order to be a good director, you really have to know all of these things. I think this technology is accessible to anybody. It's very easy, in the end, if you're moti vated and you want to be a well-rounded director, to learn most of this stuff. Like everything else, if you want to learn how to do it, you can. It's not impossible and it isn't brain surgery.

You've said that your least favorite part of the filmmaking process is principal photography – the image-gathering phase – which I assume is the reason you haven't directed a film since Star Wars. Yet you jumped back to directing with The Phan tom Menace. Was it because you wanted to, or because you felt that the whole process – work ing with minimal sets and a digital backlot – was going to be so complex and revolutionary that no one else could do it until you showed them how?

That's pretty much what it was. But to be honest, the media kind of twisted my words about directing. Somebody once asked me what my favorite part of the filmmaking process was, and my least favorite part; and from the responses I gave, it translated into: "George Lucas hates directing movies." Which I never did. I've always loved directing movies, and I always expected to go back to it. I simply got side-tracked along the way with a lot of other op portun ities that were presented to me that seemed more fascinating at the time than directing. I have always been very close to the films that I've produced. I'm a very hands-on kind of creative producer - not just somebody who sits back and watches. But I could not produce the Star Wars movies and be on the set ten hours a day. It simply wasn't pos si ble. Star Wars got very big very fast, and I had to take advantage of that, building companies and doing all kinds of things in the middle of it all. Plus there were other proj ects. I could go to Steven Spielberg, and say: "Hey, I've got this Indiana Jones character. Would you like to do this?" And he'd say: "Yeah. I want to do that." So I would find myself producing Raiders of the Lost Ark. Or Jim Henson would come to me, and say, "I have a project." And I would say: "Oh, yeah. Let's do that." So I found myself in the world of producing and building companies and develop ing technology that was an outgrowth of the frus tration I felt in trying to tell fantasy stories in this medium. In addition, I had a family that I was rais ing at the same time. So there were a lot of things I was doing that were just more interesting to me than directing. The situation is somewhat different now. For one thing, my kids are old enough that I can bring them along with me and they can bepart of the process.

But it's true that having developed this whole different way of making movies, I didn't really think I could explain it to anybody - not without having actually done it myself. On this particular film, I was bringing together a lot of ideas - and I didn't really know how to do it. So I decided I'd better do it first and figure it all out. After that, I could explain it to somebody. So that was one of the primary factors going back. Beyond that, I just felt that I had earned my

right to go back and direct, and that the com pany could pretty much take care of itself. I have competent people in place and everything operates smoothly - and I don't feel I have to be around all the time for that to happen. I can actually take off for five or six months and never be seen, and still everything runs just fine. So those were the big factors in getting me to come back.

You were doing your special editions the last time we spoke, and you outlined then your artistic reasons for wanting to go back and spruce up the first three Star Wars movies. Having seen what you did with them and what you are now doing with The Phantom Menace, I'm reminded of a story about Merian C. Cooper. When he was gear ing up to make King Kong and trying to get the most bang for his buck out of RKO, he made another film for the stu dio, The Most Dangerous Game, and built a number of key sets for it that he knew he could later use in Kong - in effect subsidizing his Kong budget with this other picture. Was there an element of that in your wanting to do the special editions?

To a degree. I was fairly confident that we could pull off what I was envisioning in the new films, but I really felt that I needed to do some concrete exper i mentation and tests to make sure that I could pull off this vision that I had. So part of it was: "Here's a small version of what we're going to do. These are the challenges." I picked certain issues and certain things I wanted to develop, and I was able to put them in categories, and say, "Okay, we're going to try these." I wanted to see how much they would cost, and what the processes would be, because to do the new films I had to take those and times them by a hundred.

Minimal live-action sets would be expanded to many times their actual size by the application of pioneering virtual backlot technology.

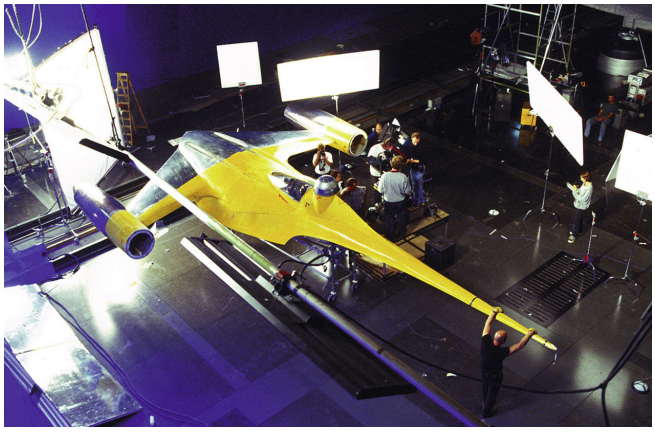
So yes, the special editions were a means of re searching and testing what I was going to try to do on this film. I had to do that. But at the same time I was able to make those movies be more the way I wanted them to be. The changes I wanted to make did not involve story issues, or anything like that - it was a matter of scope. There were a lot of things about the original films I found frustrating, because to me the illusion was too thin. Mos Eisley, for ex am ple, was a half-block long. I made a town out of nothing - and to me it felt like nothing, even though other people sort of bought it as a town. Now, in the special edition, I think it looks like a town. There are wide shots with lots of people and creatures and droids. Where before Mos Eisley was extremely simple, now it's kind of complex - things like that. Plus I was able to put my Jabba the Hutt scene back in, which I'd always wanted to do.

When we last spoke, you said that Star Wars, in its original form, was about sixty to seventy percent of what you had wanted it to be, but that you had elevated it to ninety-three or ninety-four percent with the special edition. How would you assess The Phantom Menace?I would say it’s about ninety percent of what I wanted it to be.

So your expectations have gotten higher.

Sure. The more you can do, the more you want to do. I don’t think you’re ever going to get to one hundred percent when you’re working on anything. The biggest issue on Phantom Menace is that the film is a huge experiment, just like the first Star Wars was - using technology and doing things that have never been done before - so you’re bound to make a few mistakes along the way. You’re bound to have it not be exactly the way you want it; and you’re bound to have to make compromises you’d rather not make in order to get the thing done, be cause you’re fumbling around trying to figure out what you’re doing. That’s to be expected. I’m a little older and wiser about that sort of thing than I was. In Star Wars, I was very militant about it. I was young and more uncompromising than I am now in terms of: “It’s got to be my way or not at all.” It was not until after Star Wars that I began to realize that’s not the way the world works. So I’m very happy with the way this new film has turned out. What’s been accomplished is a major feat. What ILM has accom plished, the whole way the movie has been put to gether - it’s just amazing.

The central hangar in Theed – a partial set constructed at Leavesden Studios in England – would be rendered enormous via postproduction visual effects.



A full-size mockup of a Naboo starfighter is filmed on a bluescreen stage.

Back in the ‘old days’ of Star Wars and Close Encounters, it was common for big special effects movies to have a year of postproduction effects work. Today, postproduction schedules are being compressed to the point where some times there’s only three or four months from the time the main unit wraps to the time the film’s released. With The Phantom Menace you seem to have reversed that trend by speeding through principal photog raphy in something like sixty-five days and then spending twenty months in post. Is that a good model – economic and otherwise – for this type of filmmaking?

I believe strongly that you need to be rational about what you’re doing. Fortunately, I’m in a situ ation where I control the picture, and the financing and the making of it. I can simply say: “How do we do this? How long is it going to take us? How much will it cost?” My decisions are not driven by market ing decisions - “we’ve got a release date of X and we’ve got to be finished by

this time in order to make it” - but rather by whatever it takes to make it right. Originally I was going to release the film a year ago, or two years ago. But as we were planning it and putting it together, we realized: “We can’t do that. It’s just not going to happen.” So we pushed it down, because I wanted to make sure we had plenty of time to do it in. Still, you’re always rushed, no matter how you go about it. Even though we spent four years on this film, it’s been a mad race right down to the very end. But nobody’s panicked. We’re not cutting things short to get things out, or com promising in terms of the artistic integrity of what we have to do. That’s very important.

Right now, to do a fully animated film takes about eighteen months to two years. I have a feel ing that’s going to speed up as the technology gets more sophisticated, and we’re going to be able to move that down. I’ve been pushing very hard in non linear editing to get the ability to cut sound inte grated with the picture - which hasn’t happened up to this point. What I always like to do is hire my sound department at the same time I start shooting my picture, so I can be cutting sound and picture at the same time. When we develop a more integrated post system, and are able to get everything going much better and faster in terms of special effects and get them started about the same time we shoot, we’ll be able to condense the time down consid er ably from where it is now. Right now, we’re still a bit locked into the assembly-line process. I’ve done a lot to break that up, but in many instances we still have to finish one thing before we can start the next. I would like to be able to start everything all at once.

You mentioned eighteen months or more to do an ani mated film. Do you see Phantom Menace as being more akin to an animated film than a live-action film?

Well, it’s about fifty-fifty. We have 2000 effects shots - actually 1985 or 1986; we just round it off - and there’s probably animation in most of those, either character animation or set animation, since a lot of our sets were 3D. So that’s a big factor in the way this movie is made. As far as I know, this is the first truly digital photorealistic film that’s been made with photorealistic sets and photorealistic characters. I would say more than half the sets are not real, and about half the characters.

What did you learn from making this film that surprised you? And what will you do differently on the next one as a result?

Mainly I was surprised at the extent to which I could manipulate images. I had no idea going in that I could manipulate things as extensively as I have on this show - especially through the use of nonlinear edit ing and all the bells and whistles available with that. I just didn’t think about it. But having the whole film digitized meant that it didn’t really cost me any more to move things - it was a very simple process. So I started moving things all over the place - and it’s really changed the way I think about movies. I went into this film with the attitude that we would capture whatever we could as quickly as we could, and then go back in later and fix it and manipulate it. But the ability to do that was far beyond anything I’d imagined; and I think that will affect the way I shoot the next film, with regard to how much time I spend on certain things. We built a little bit more in terms of sets and stuff than we really needed. With this technol ogy, we can keep reducing down the parts that we actually have to build. As for using digital charac ters in the scenes, I think I can do it faster and eas ier now than I could before,

even though I'd done quite a lot of it. Tremendous advances continue to be made. And photographically, it's just completely free now. It used to be you had to sort of lock cam eras down and pay attention to things like that. Not anymore. Dollies and booms - I can do almost any thing now. I don't have to be as timid as I was.

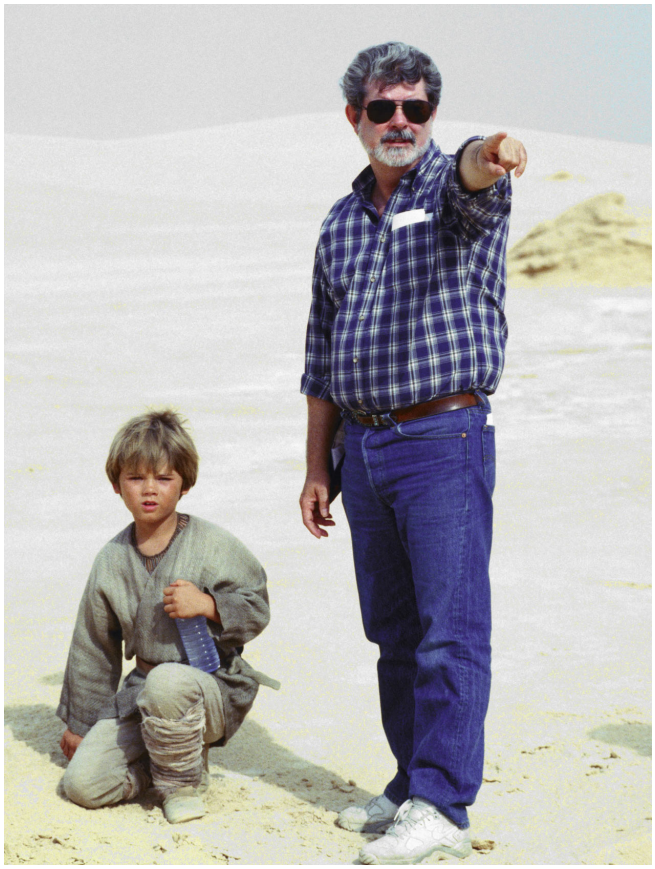
I understand that on the next picture you've decided to bypass film altogether and shoot the entire movie on high-def video.

During a regular visit to the ILM model shop, producer Rick McCallum and Lucas are shown an unfinished Federation battleship laser cannon by model shop supervisor Steve Gawley.

I prefer to call it digital - but yes. We shot part of this film digitally and integrated it into the pic ture; and I don't think anybody can tell which shots are digital and which were done on film. So we're build ing cameras and lenses, and we're going to shoot the next one all digitally. The process of going from film to digital and back is very cumbersome. The conversions and all are a pain, and they cost a huge amount of money - and there's no point in it. So I'm very keen to get us all digital, even to the point of the theater presen ta tion. Next time we're going to shoot everything digit ally; and then it will all go into computers, just as it does now, and I'm hoping that by the time we finish the movie there'll be a fair number of theaters that are also projecting digitally. If we didn't ever have to go to film, it would streamline my process and the special effects proc ess tremendously. And it would cut our costs by twenty-five percent - which is a big deal.

The last time I asked, you told me you thought ILM was about three years ahead of the competi tion. That was three years ago. Where do you feel they are now?

I think they're at least five years ahead of the pack. I don't think anybody else comes close to the kinds of things ILM is doing now. We can do the kind of performance animation that Pixar does in their cartoons - but we can do it photorealistically. Other companies are doing computer animation and computer characters and such, but nobody is able to do it the way ILM does in terms of creating photorealistic characters that look real within a scene. Centropolis is the only other company that's tried to create the kind of 3D characters that ILM has - with Godzilla - and they did an okay job. But compare it to Jurassic Park - which we did six or seven years ago - and I still think Jurassic holds up better. If you pull some of the shots apart and study them a bit, you see they put their character in the rain to try to hide things, while ours are out in broad daylight. And now we've been able to get our CG characters to act. I was kidding with Steven a while ago. I said, "You know, Steven, you got ILM to tame the dinosaur - but I've now taught the dinosaur to act." And that is the difference.



Wearing a trademark flannel shirt – even in the blistering desert heat of Tunisia – George Lucas blocks out a scene with Jake Lloyd.

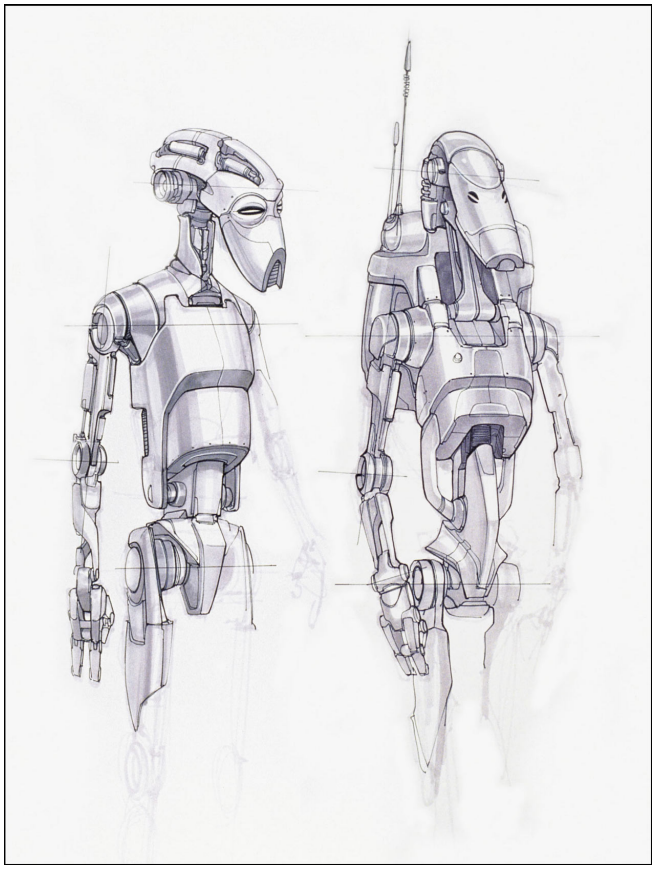
Star Wars Episode I: The Phantom Menace photo graphs copyright © 1999 by Lucasfilm, Ltd. All rights reserved. Production still photography by Keith Hamshere. Special thanks to Lynne Hale, Jeanne Cole, Tina Mills and Karen Rose.

PHANTOM VISIONS

ARTICLE BY Mark Cotta Vaz

It is poetic that the creative Mount Olympus for Star Wars Episode I: The Phantom Menace was located within the main house at fabled Skywalker Ranch, that pastoral edifice built on the success of the original Star Wars trilogy. The Victorian-style building's spacious, sunlit top third floor was where everything in The Phantom Menace universe was conjured, from belt buckles to battleships, from creatures to entire worlds.

In one main work area, past a table filled with sculptures and walls covered with storyboards and concept art, was a cozy little cul-de-sac, the personal work space for design director Doug Chiang. A six-foot-tall battle droid sculpture, courtesy of ILM, stood at a wall pinned with Chiang's pen-and-marker sketches of aliens, vehicles and spacecraft – all ideas rejected by George Lucas. Tacked above was a tongue-in-cheek sign: 'Wall of Shame.'



Most of the character and hardware designs for The Phantom Menace – produced over a four-year period by design director Doug Chiang and his concept art department – went through numerous iterations before final approval. Two battle droid designs – one early and one final – by Chiang.

But an adjacent wall was filled with Chiang's finished acrylic paintings of fully realized scenes: Gungan soldiers mounted on kaadu, Theedians and Gungans meeting in a mysterious swamp choked with ancient ruins, dark clouds rolling over a wind-swept plain of Naboo, Federation attack vehicles crashing through jungle foliage, Tatooine's imposing podrace stadium. A continuous stream of drawings, sculptures and

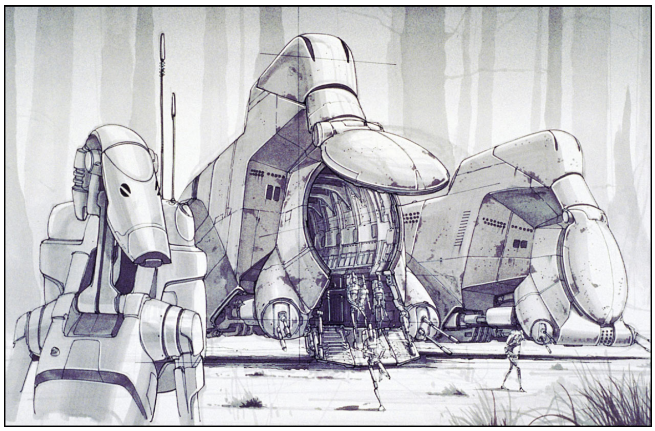
storyboards, produced over a period of two years, had gone into those beautifully realized paintings.

In those renderings was an echo of the work of conceptual artist Ralph McQuarrie, whose production illustrations had laid the visual foundation for the original Star Wars trilogy. Indeed, Chiang cited McQuarrie and Star Wars effects and design illustrator Joe Johnston – now a successful film director – as major inspirations. “I’m in this business because of Ralph and Joe,” Chiang said, recalling the revelatory Art of Star Wars books he discovered in high school. “There was something about Ralph’s style that was very accessible, and inspired me to do my first painting – a space station. It was the usual boyhood fantasy.”

The journey from that first space station painting to The Phantom Menace renderings had taken Chiang through a stint as an ILM art director, working on movies such as Terminator 2, Jumanji and Death Becomes Her – for which he won an Academy Award. When the opportunity to work on the new installment of the Star Wars saga presented itself, Chiang submitted concept art, done on his own time, which impressed Phantom Menace producer Rick McCallum enough that the artist soon found himself leading the conceptualization process. Under Chiang’s direction, the concept unit would prove to be the integral link between George Lucas’ visions and their realization as physical sets and props, miniatures, virtual backlots and characters both digital and practical.

The design department, which set up shop at Skywalker Ranch in January 1995, would, for some eight months thereafter, consist solely of Chiang and former ILM artist and freelancer Terryl Whitlatch. Industrial Light & Magic's involvement in the project was still two to three years away, and most of Lucas' ideas had yet to be put to paper. Ahead lay a blank slate, and the daunting challenge of whole worlds waiting to be created.

As the concept work evolved, the department would grow from a core group of five to a full staff of seventeen. Production designer Gavin Bocquet came aboard a year after Chiang's hiring to contribute additional designs – interior sets in particular – and to see concepts through to their construction on soundstages at Leavesden Studios in England, where the production was to be based, as well as on location in Tunisia and Italy. Within that first year, ILM computer artist David Dozoretz also joined the creative beehive on the third floor, producing computer animatics for a key action sequence involving a high-voltage aerial podrace in which young Anakin Skywalker pilots his home-built racing pod to victory. Dozoretz would ultimately supervise a breakthrough use of the previsualization tool for the production.



A Doug Chiang sketch of battle droids being deployed from mobile troop transports during the Federation invasion of Naboo.

For a period of many months, Lucas was formulating his screenplay in parallel with the concept development; and weekly brainstorming sessions with the director afforded unique insights into the creative process for Chiang, Whitlatch and others in the unit. As ideas took shape through the concept art, some were discarded by Lucas and others swapped freely between worlds. Having originally imagined levitating observational platforms for race viewers in the podrace arena on Tatooine, for example, Lucas subsequently elected to put that concept to use in a later scene involving a senate meeting on Coruscant, the galactic capital. Beasts of burden called kaadu, originally intended to pull Anakin's pod engines into the race arena, ended up as pack animals for the Gungans, an amphibious race inhabiting the watery regions of Naboo. The creative process continually kept the artists on their toes. "It was fascinating to see what George was thinking and writing," Chiang observed, "and wonderful the way he swapped ideas around, because it forced us to take a design and find ways to adapt it to different environments."

Sometimes Lucas was specific when proposing an idea, at other times inscrutable. Chiang would instruct his artists to take a concept in three aesthetic directions – conservative, down the middle and 'way out there' – thereby giving the director wide-ranging choices. An approved concept would continue to evolve in sketches or be taken toward a final design with sculptures, mockups and storyboards. "George allowed us to design without any preconceived ideas," said Chiang. "The result was a richness of concepts, a layering of textures."

The grand design ambitions forced the concept artists to think like storytellers. For Chiang, the production was a major change from ILM, where the art department ordinarily dealt with already determined designs, and was not as intimately involved with a director's vision. "In the beginning, all of us tended to over-design, to make things a bit too complicated. George taught us that if an audience cannot recognize and understand a form in three seconds of screen time, or less, then it's not going to work. That forced us to design in simpler terms. After we got simple shapes and silhouettes going, we could then layer in the details. One of the great things about the original Star Wars was that everything had a strong design integrity. You could describe a vehicle in simple shapes; but if you looked closer, there were all kinds of design details. Once we understood that, it made a huge difference in how we designed all of the elements."

Although Lucas challenged his artists to come up with things never before seen, Chiang recognized that a hybrid approach – mixing and matching the unfamiliar with the familiar – was equally important. "When creating alternate universes," Chiang explained, "you have to be careful not to deviate too far from reality. One of the reasons the original Star Wars worked so well was that it had a strong basis in reality." It was a philosophy Lucas referred to as 'reality with a twist,' and one that had been liberally applied to the original three films, where designs such as Princess Leia's cinnamon-bun hairstyle – which was based on Hopi Indian headdress – frequently owed their inspiration to the diverse wellspring of existing world cultures.

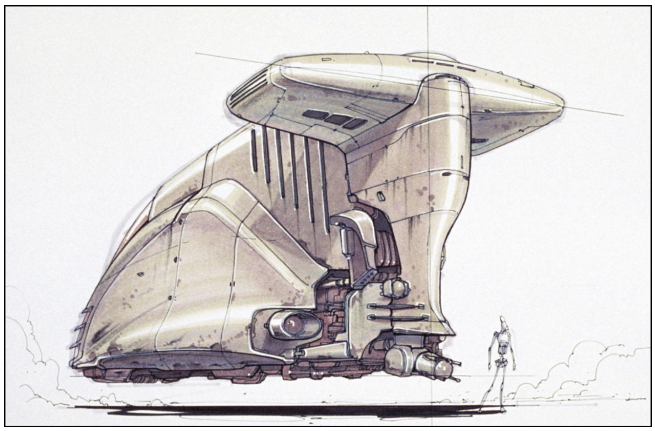
The Phantom Menace would also reflect such influences – from the painted visage of the sinister Sith lord apprentice Darth Maul, whose eerie facial tattoos resembled those of particular indigenous tribes in the Brazilian rainforest, to Asian cultures reflected in the royal robes of Queen Amidala, ruler of the peaceful planet Naboo. In fact, African tribal art would serve as inspiration for one of Chiang's earliest assignments – conceiving a robotic army of battle droids, deployed by the scheming Neimoidians during a Trade Federation assault on Naboo. Lucas had envisioned the droids as predecessors to the Imperial stormtroopers introduced in the first film, a description Chiang took literally prior to revamping the stormtrooper designs to reflect the stylized, elongated facial features of human sculptures found in certain primitive tribal art.

A design's emotional impact was also a consideration in approaching the work, particularly with battle hardware. Designs for objects and machines were frequently imbued with subtle suggestions of animate attributes to heighten an audience's emotional response to them. An example was the Federation's mobile troop transports – or MTTs – used to convey the battle droids on Naboo. "When you imbue a design with certain shapes," Chiang noted, "it can trigger instinctive reactions. For the MTTs, George said he wanted a floating locomotive-type thing that could plow through trees. The mental image that came to my mind as he described it was that of a charging elephant. So I started designing a train form with suggestions of an elephant – two side arms with guns placed like tusks, and a seam dividing two portholes in the cockpit that looked a bit like eyes. It turned out to be one of those elegant solutions, because the elephant features also gave the design a lot of personality, even if those features weren't immediately evident. We strove to give all of our vehicles that sense of personality."

The Federation's armored attack tanks – or AATs – were also imbued with predatory characteristics. "George wanted a fast moving, fearsome attack helicopter," Chiang observed. "At one point it was literally going to be a flying turret. I offered two different drawings – one tank-like, the other shaped like a flying spade – and George thought it would be interesting to combine both forms. Then I began elaborating on that design with some animal characteristics – such as the front-side rocket ports, three on each side, which reminded me of the claws of a pouncing lion."

Unlike the animal influences shaping MTT and AAT designs, the destroyer droids – deadlier versions of the battle droids – and the Federation landing craft that deliver the invasion forces to the surface of Naboo, owed their creepy, unearthly look to insects. The idea for the destroyer droid evolved from an earlier battle droid concept that had the robots navigating by curling up into a ball and rolling instead of walking. That method of movement would eventually be incorporated into the destroyer droid, which had a spheroid body, curved back and three legs literally forming a walking set of guns. "In an attempt to make it even more fearsome," recalled Chiang, "George then suggested that we look at insect references – so it became spider-like."

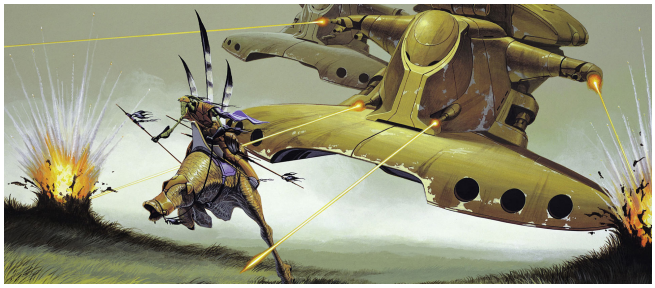
For the Federation landing craft, the designers played with forms ranging from a dirigible to a classic spaceship, before Chiang hit on another insect-inspired idea. "Since the personality of the droid army is somewhat animal in nature, I started looking at primordial references – specifically ancient dragonflies, which had these huge four-foot wingspans. With that as inspiration, the landing ships evolved into two giant sets of wings, with no fuselage. What was wonderful was that this design also resembled an old biplane which gave it more of a historical reference."



An early concept for the mobile troop transport – by Doug Chiang – featured design elements suggestive of a charging elephant.

Organic design attributes also lent personality to the Trade Federation's fleet of space battleships, from which the Neimoidian invaders oversee their assault on Naboo, and to the flying Jet-ski-type conveyances called STAPS, ridden by the attack droids on the planet's surface. The STAPS, a variation on the speeder bikes featured in Return of the Jedi, took their cue from the fluttery look of hummingbirds, with sleek heads and tiny wings. For the Federation battleships, Lucas had originally envisioned classic flying saucer shapes – circular versions of the Imperial Star Destroyer. However, as the design process unfolded, he began to favor a more exotic look. The end result took the shape of a donut, with a section removed. Lucas then added a bit of backstory that helped Chiang finish the design. "George described the battleship as being disguised to look like a freighter," Chiang related, "so I added large grabbling arms to the front section that could be used for docking – a design element that gave it a crab-like personality."

Other hardware designs reflected the unique social Evolution of the various cultures inhabiting the worlds of The Phantom Menace. As a way of providing such distinctions, Chiang utilized an approach that he termed ‘technology as art,’ which sought to emulate the ethos of hand-crafted technology – much like the prototypal vehicles built by craftsmen in the early decades of the automobile. Thus, the various cultures expressed their own distinct design aesthetic through their technology – whether it was Queen Amidala’s elegant spaceship reflecting the sparkling sophistication of Theed, the capital city of the planet Naboo, the squid-like submarines of Naboo’s underwater Gungan empire, or the gritty podrace vehicles crowding the field of Tatooine’s celebrated competition.



In addition to countless drawings, Doug Chiang produced dozens of color paintings showcasing various aspects of the design work. During a fierce ground battle on the plains of Naboo, an armored attack tank chases down a Gungan cavalryman, mounted on a kaadu.

The podracers – created for a ten-minute-long seqment that was an action centerpiece of the film – would speak volumes about the disparate alien lowlifes seeking refuge in Tatooine’s desert outpost of Mos Espa. Among those working on designs for the racing vehicles was Jay Shuster, a young artist who had taken a circuitous route to the Ranch, with stops that included stints with Alias/Wavefront in Toronto and Rocket Science Games in San Francisco. Working in the Star Wars universe had been a dream of Shuster’s since the age of six, and he was understandably overwhelmed at the outset. “When I came on,” Shuster remarked, “it was amazing to see the body of work Doug Chiang had already completed. I was in his office, looking at his Wall of Shame, and all I could think was: ‘Damn! If I’m ever this good...’ It was stuff that would have been A-list ideas on any other movie.”

Chiang had originally enlisted Shuster to work specifically on podracer designs – a proposed two-week gig that eventually stretched to more than two years, as the artist went on to address various gadgets, vehicles and environments. But the podracer design was Shuster’s plum assignment, parti-cularly since he had grown up in Detroit and was steeped in a love of automobile design, with an instinctive feel for Lucas’ ‘used universe’ approach to vehicles and machinery. “Star Wars designs were always believable,” commented Shuster, “with that lived-in look most filmmakers fail to recognize as important.” A lifelong race car fan, Lucas had been unequivocal about his idea for the podracers, envisioning them as flying chariots tethered to giant, high-powered twin engines. “What was so successful about the TIE-fighters and X-wings in the previous films was their very simple form. So the basic design mandate throughout was to simplify things. The podracers were extraordinary examples of that, as each had to read visually in mere seconds.”

The assignment was approached on two fronts – through sketches and the ‘kit-bashing’ technique of assembling existing model parts into protopods. Twenty-three unique vehicles were designed – including several done in England by Gavin Bocquet and Kun Chang – eventually trimmed to eighteen. Although Lucas had given the designers wide creative latitude in developing the individual looks of the various race vehicles, the director took particular

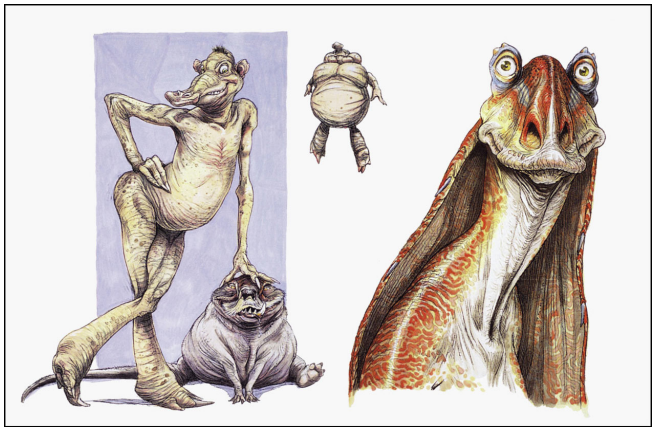
interest in Anakin’s podracer. “George wanted me to emulate the design of the Maserati Birdcage – a favorite car of his from his youth,” remarked Shuster. “The Birdcage was like a roll-frame, made entirely of intricate tubes welded together. The pod had high fenders front-on, which framed the driver nicely. The metal was beat-up – like from a scrap yard. Then I added technological textures such as little knobs, vents and wires.”

For Sebulba, the competition's perennial, but morally-challenged champion, Shuster created a racer befitting the character's ruthless persona. "I hacked parts of a model kit from an A-10 Warthog," Shuster elaborated, "a modern tank-killer airplane that has two rear-mounted engines and a big gatling gun out the front. I cut the thing in half and turned it around so the gun was actually sticking out the back of Sebulba's chariot. It was a sweet-looking vehicle." A final touch for all the pods were painted designs, inspired by the logos from professional racing-circuit cars, embellished by Shuster to include exotic influences such as arabesque patterns, Japanese characters, Native American designs and 'rave' graphics.

At the opposite end of the spectrum from the seedy pod vehicles was the apotheosis of Naboo's Theedian culture – the exotic, glittering-chrome queen's ship, used to make good Amidala's escape to Coruscant where she intends to plead her cause before the senate of the Republic. The design for the regal ship reflected both the queen's elegance and the idealistic culture of Theed, though its es-sential form was derived from the ultra-sleek SR-71 military reconnaissance plane. "The same way the space shuttle exemplifies the power of technology in America," said Chiang, "so does the queen's ship represent the culmination of all Theedian technology. Theed's technology is not explicitly explained, but it's implied that its craftsmen have the power to shape these large, smooth, virtually seamless fabrications. I added a few art nouveau touches as well, such as long spikes on the ship."

The design aesthetic of the queen's ship was repeated in her fleet of Naboo starfighters, whose shapes were inspired by classic car hood ornaments – enhanced with elegant touches of art nouveau. While the single-seat craft had a martial form that conveyed their function as protectors of the realm, their designers also sought to emulate the royal ship's refined chrome look. "The starfighters were another example of machine as art," Chiang noted. "There are design details, such as the sweep of the wings, that have no practical function, but are there purely for visual pleasure." In fact, the ships would undergo a late-stage refinement after the physical maquettes had been completed, solely for the sake of aesthetics. Although Lucas had approved all of the concept art, once he saw the physical model he felt that the rocket port, which was located by the cockpit, hurt the lines of the form. "George told us to eliminate the rocket port. Doing that gave the whole thing a sleek, racecar line that was perfect." The starfighter hangar, where the ships are docked, would undergo some refinement, as well. "The idea there was to fit the starfighters between the hangar columns, and make a maintenance bay for each fighter," explained Jay Shuster, who designed the giant structure. "At first the fighters were going to be stacked and levitate in place above each other. The final look had the fighters each in their own bay, secured and not floating."

Besides delineating various cultures through their technological hardware, The Phantom Menace design team also had to devise whole environments that would visually read as different – from the barren deserts of Tatooine to the marshlands of Naboo. Urban landscapes such as Coruscant – center of the Star Wars universe – twisted the reality of earthly cities through exaggeration. Envisioned by Lucas as New York on a global scale, Coruscant would be revealed through scenes taking place in distinct and recognizably different settings – in particular, the senate building, Palpatine's quarters and the Jedi council chamber. Expanding on concept paintings produced by Ralph McQuarrie for the first movie, Chiang created a sleek super-metropolis, whose corporate, ultra-modern senate building and architecturally awe-inspiring Jedi temple comprised its centerpiece. A dark industrial district was also designed. "This is the seedy side of Coruscant," said Shuster, who contributed to the concept, with Ed Natividad and Kurt Kaufman. "This is where Darth Maul and the Emperor meet on a balcony overlooking an ominous cityscape. It was inspired by the general look of Coruscant, but had more of an industrial aspect to it – like oil refineries belching flame and smoke."



Jar Jar Binks – a computer generated Gungan – was the most difficult design assignment on the film since he was a major character who had to interact throughout with the human cast. One of the early concepts – by artist Terryl Whitlatch – evolved over time into a tall amphibious creature with eye-stalks and huge floppy ears.

In sharp contrast to Coruscant, the classical architecture and waterways of Theed derived their inspiration from Venice, with the artistic spirit of the pre-Raphaelites pervading the city's dreamy atmosphere. "Theed was George's version of paradise," stated Chiang. Water would be an important aspect of Theed, providing a natural barrier between the city's peace-loving people and the amphibious and more primitive Gungans. "George wanted the planet to be two worlds. The queen's world would contain forests and rolling green hills, while the Gungan's world would be a primordial environ-ment of swamps and lakes."

In an early drawing of Otoh Gunga – by Doug Chiang – the bubble structures of the underwater Gungan city were embedded in a rock wall.

Otoh Gunga, the underwater city inhabited by the Gungans, would be far more alien-looking than Theed, reflecting as it did a bizarre culture that had very little in common with the land-based inhabitants above. Hard to pin down, the Gungan city went through numerous iterations. Lucas had originally described his vision of Otoh Gunga as a 'world of bubbles,' a magical vision of spheres of light energy at the bottom of the sea. Since the Gungan culture, like that of Theed, was attuned to nature, the organic floral shapes of art nouveau figured into the design of its strange architecture. Exotic forms, however, soon gave way to exotic function. "The design slowly evolved from the bubble look to a force-field technology that had the Gungans able to capture air in individual bubbles," said Chiang, "with art nouveau ribs to bind them together. So Otoh Gunga became a cluster of bubbles organically grown, each one an individual force-field sphere."

Populating all of the fantasy environments conceived by the art department was an array of even more fantastic inhabitants and indigenous animals. Literally thousands of drawings were produced in an effort to pin down the various alien creature designs. New and fantastic species were frequently conjured by mixing and matching traits and features of real animals – an approach that benefited enormously from the contributions of artist Terryl Whitlatch. Whitlatch, whose short stint at ILM had included designing hybrid monkeys for Jumanji and dewbacks for the Star Wars special edition, had pursued a career in zoology before becoming an artist. That mix of artistic talent and animal expertise had won her a reputation as something of a specialist in creature design.

Among the assorted environments, Tatooine – with its array of nonindigenous species grudgingly sharing a cooperative existence – provided the designers with some of their best opportunities for creative expression. Besides an abundance of background characters, a key design task involved The Wild bunch of drivers pitted against one another in Tatooine's grueling

podrace competition. Lead podracer and villain of the sequence was Sebulba, a creature Whitlatch endowed with a purple-skinned gibbon body and the face of a camel. Sebulba had another strange physiological aspect that grew out of a suggestion from Lucas. “George wanted a mean podracer,” commented Whitlatch, “and as an afterthought, he asked: ‘What if this guy walks on his hands and drives with his feet?’ So, that’s what I had to work with.”

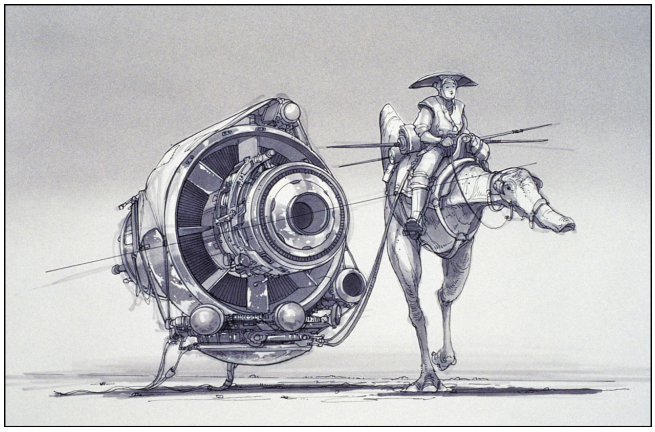
Lucas wanted each of the podracers to have a distinct profile. For Sebulba he had pictured something odd, almost disturbing to look at. “He liked the idea of the spider monkey form,” Chiang noted, “and once we locked into that, we were able to go in and find the details – the personality of the face, how many teeth, and so on. Terryl combined different features from different creatures, which was the general design philosophy George preferred. It was wonderful to see all these weird features come together to create characters with lots of personality. It doesn’t sound like it would work, but it always wound up being something stronger than the individual elements themselves. Sebulba is the perfect example of that, and Watto is another.”

Watto, a petty Mos Espa junk dealer to whom Anakin Skywalker is indentured, was described by Lucas as having the head originally intended – and later rejected – for the Neimoidians,attached to a cherubic body, with small hummingbird-like bat wings and duck feet. “At first, when he described all those features, I thought: ‘Surely he doesn’t want that literally,’” Chiang commented, “so we did our own interpretation of Watto, and the following week George said: ‘No, no, no,’ and described him again, the same way as before. I ended up drawing exactly what he wanted – and it worked! Watto was actually one of the first times I realized that George had all the characters in his head before we even started drawing. It was just a matter of getting those ideas from his head to our paper.”

Whereas the majority of inhabitants of Naboo were human in form, the denizens of Otoh Gunga were not. The first Gungan to be designed was the comical Jar Jar Binks, the production’s lead digital character – an assignment that once again went to Whitlatch. But Jar Jar’s form remained elusive, even as Whitlatch developed characters from podracers to swamp creatures. Other than an outline of a tall, amphibious character, the prime Gungan remained on her drawing board, unfinished. “I knew Jar Jar was supposed to be bumbling, yet earnest – a misfit,” recalled Whitlatch, “because George had told me more about Jar Jar’s personality than what he specifically looked like. What helped me figure it out was thinking about real actors who might be like Jar Jar – Charlie Chaplin, Jimmy Stewart, Danny Kaye. I particularly thought of Kaye, a sympathetic and funny guy, but not a total klutz. Gangling, but with grace.”

In the span of a few months, the character contracted and expanded in spasms of Evolution and devolution. Early on in the process, Lucas had toyed with the idea of making Jar Jar pressure sensitive so that his size and shape would alter with differing atmospheric conditions. In space, the low-pressure conditions would make the character appear fat; while, underwater, he would look thin due to the effects of high pressure. After more consideration, Lucas realized the approach would complicate the story and increase expenses without really enhancing Jar Jar’s personality. Consequently, the shape-shifting idea was dropped.

The creative break that led to Jar Jar's design came when Lucas walked into the art department and spotted some rough sketches Whitlatch had pinned to her bulletin board. The sketches were of a frog-like creature on its hind legs, its eyes on stalks, its face depicting a worried expression. "They were just doodles I had done for my own enjoyment at ILM," Whitlatch noted, "probably when I needed a break from drawing monkeys on Jumanji. George saw the sketches and liked them. So that worried little frog creature became 'proto-Jar Jar.'"



Anakin – mounted on a kaadu – tows a pod engine across the Tatooine desert in a drawing by Doug Chiang. The kaadu was later to become indigenous to Naboo, necessitating the design of another beast of burden for Tatooine.

From that creative breakthrough, the Gungan developed via the usual amalgam of influences. To avoid the obvious froglike look of an amphibious creature, Whitlatch's instincts led her to the hadrosaur, a duck-billed dinosaur. She made Jar Jar's neck like that of a swan, with his form and gait suggestive of the flightless emu. Lucas proposed long, puppy-dog ears, which Whitlatch made webbed, in the manner of fish fins. As Jar Jar evolved, the design was executed in various mediums to consider the character in its full dimensions. Whitlatch made a small styrofoam sculpture. Line art was blown up and put onto a full-scale cardboard cutout so that Lucas could determine how the figure would work in relation to actors. Helping considerably to get the design on track was sculptor Tony McVey, who produced a maquette halfway through the development process that, with further refinement from Whitlatch, Chiang and concept artist Iain McCaig, eventually became Jar Jar. A year and a half would pass by the time the final look was approved. "I thought about Jar Jar constantly all through the process," stated Whitlatch. "I'd ask myself, 'Will there ever be a design George likes?' And then, finally, there was."

Anakin's podracer – designed by Jay Shuster – was one of twenty-three unique vehicles created to differentiate individual drivers in the race.

Yet to be determined was how such a character would be realized. Though an entirely man-in-a-suit approach was never an option, Lucas did consider tracking a CG head onto a suited performer's body. ILM animation director Rob Coleman tested the idea and discovered that tracking a CG element to a performer would be more laborious and less satisfactory, in the end, than doing the entire character digitally. Lucas dropped his initial notion, and Jar Jar was designated an all-digital character. "Everybody in the art department cheered when we heard

that," Whitlatch recalled. "We all felt that Jar Jar would look much better without the restrictions of a human being in a suit." Other Gungan designs – though distinctively individual – were essentially modifications on Jar Jar's final look.

One of the curious aspects of Gungan culture was that while the city was built on sophisticated force-fields, the Gungans inexplicably depended on beasts of burden for transportation – a menagerie that included strange creatures called kaadu and fambaas. The two-legged kaadu was originally designed for Tatooine as a mount for Anakin to ride, in the manner of the tauntauns ridden by Luke Skywalker and Han Solo in The Empire Strikes Back. However, it later became a victim of one of Lucas' design-swapping urges and was transplanted to Naboo, where it served instead as a mount for the Gungan cavalry. To replace the kaadu on Tatooine, the design team came up with a new animal called the eopie – a camel-like beast of burden with fur and other features that were fitting to the harsh desert environment.

The exchange meant that Chiang and his team had to redesign the kaadu to fit Naboo's watery environment. "Since it was no longer a desert creature, but a swamp creature," Chiang recalled, "the skin became a bit more supple, the mouth more aquatic. I have a tendency to come up with things that are kind of impossible, so the kaadu evolved from a two-legged dinosaur without limbs. Terryl, our authority on animal biology, managed to take that impossible design and make something out of it."

Reptilian features would also be extended to the fambaas, another indigenous Gungan animal, with skin texture that emulated that of a sea turtle in deference to the aquatic characteristics of the Gungan world. Seen by Chiang as a sort of new species of dinosaur – a blend of rhinoceros and triceratops – the fambaa was a lumbering beast whose main purpose was to carry the shield generators the Gungans would utilize as a defense against the battle droids' firepower in The Phantom Menace's final confrontation.

Also populating the Gungan underwater world were giant sea monsters. Three creatures of the deep were designed for a sequence in which Jedi knight Qui-Gon Jinn, his apprentice Obi-Wan Kenobi and their persistent sidekick Jar Jar – in a Gungan submarine – navigate the treacherous waters beyond the city of Otoh Gunga. Not only would these deep-sea denizens reflect the high-pressure underwater reality of the kingdom of Otoh Gunga, all would represent a bizarre mix-and-match of real-world animals and sea life.

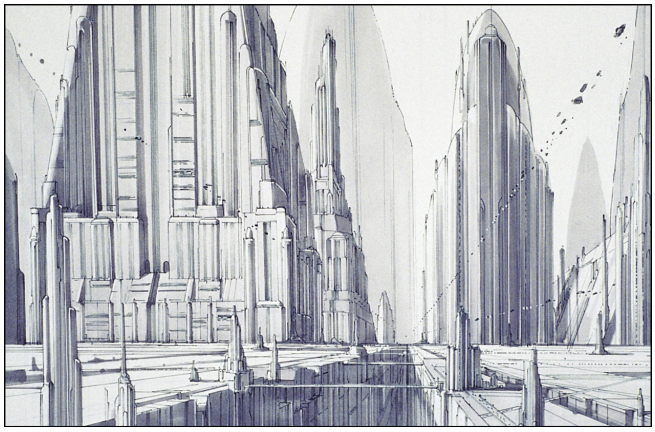
The first of the beasts encountered by the sub is the giant opee sea killer, which nearly swallows the vessel and its occupants whole when Jar Jar accidentally kicks the ship into reverse, sending it directly into the monster's mouth. Designs for the opee sea killer took the head of a deep-sea angler and fused it to a crab body that itself was adapted with a lobster's segmented form. For the even larger sando aqua monster, which munches on the opee, Terryl Whitlatch followed Lucas' directive to conjure up a whale-like creature the size of an ocean liner, creating a head that fused tiger and mythical dragon features. Before it was finished, the sando had transmuted into a whale's head attached to a serpent's tail. A final underwater encounter was with the colo claw fish, an eel-like creature fitted with an alligator mouth and pincers extruding from its jaws.

Once most of the major design aspects of the new Star Wars universe were completed by Chiang and his team, some members of the group turned their attention to storyboarding sequences Lucas had by then locked in screenplay form. But for several of the more complex, action-packed scenes, Lucas had known that storyboards alone would not suffice. In September 1995, animatics supervisor David Dozoretz, the first computer artist to be hired for the picture, joined the design team and began work on CG animatics for the crucially important podrace scene. Dozoretz's prior previsualization experience had been with ILM visual effects supervisor John Knoll on a Mission: Impossible sequence in which a speeding train was chased by a helicopter. It was that work that had prompted Rick McCallum to recruit Dozoretz for the Skywalker Ranch team. But while those animatics had been accomplished with simple stick figures, Phantom Menace pre-viz tools – whichranged from Electric Image software on Macintoshes to ILM in-house software on Silicon Graphics machines – produced images that were akin to a commercial video game's high-resolution graphics. Textured and shaded digital models were animated in 3D and composited with elements that ranged from hand-drawn storyboard images to live-action video – of a young stand-in for Anakin or a reference puppet of Sebulba – and sky plates shot for the podrace. Final animatics were subsequently displayed on an Avid nonlinear editing system or projected in a screening room.

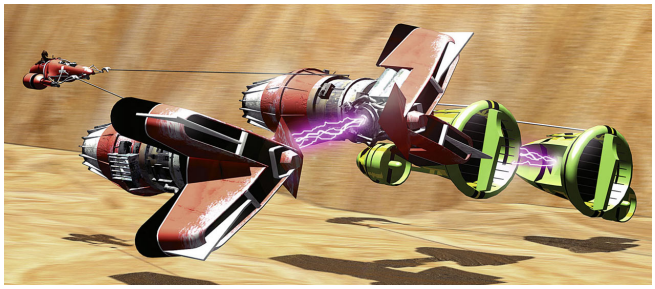
"We took pre-viz up a notch," related Dozoretz, whose team would eventually grow to eight artists. "One of the unwritten rules of animatics is to keep things rough. You want people judging images for the right things, such as blocking and pacing, not photorealism. But for sequences like the podrace, we had to be more detailed. We were trying to communicate speed – and the way to do that is by having detailed terrain going past camera quickly. So we had to add textures, shadows, motion blur – all the 'no-nos' of pre-viz." Even so, the primary goal of the previsualizations was not ILM-style perfection. Time was always of the essence. Some of the model concepts were worked up in just minutes – and animated nearly as fast. In crunch situations, as many as seventy-five animatic shots were done in a sin-gle day. "We were George and Rick's garage film department – with a real film-school mentality. We'd slap textures on a model to create a general impression, then crank things out really fast."

The freedom to quickly compose models and sequences appealed to the natural editor in Lucas, and the demand for pre-viz shots grew at a steady pace. Ultimately, animatics were created for all of the major sequences, from the podrace to the final space and ground battles. Spaceships were built and configured in planetary orbit or streaking into hyperspace, and all classes of droids and vehicles were constructed and put into motion in previsualized environments. Set extensions, which ILM intended to create digitally as a method of carrying practical sets to towering heights, were also composed in the animatics concept stage. As the unit grew and its activity increased, the pre-viz effort made such a draw on the electricity in the main house that new power had to be installed to accommodate the computing machines. By the end of production, as much as eighty percent of the film had been plotted out in animatics.

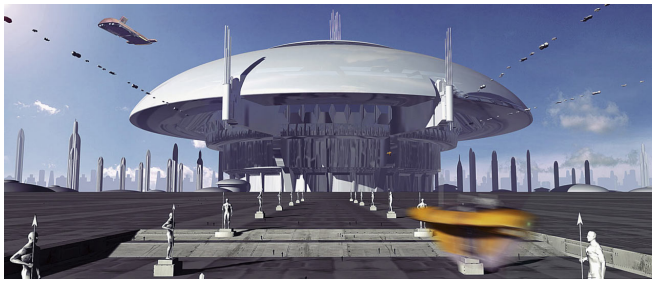
The pre-viz group supplied its animatics files to all departments, including the production art department, where Gavin Bocquet found them to be a handy 3D reference as he considered the construction of vehicles, size of set walls and other design concerns. At ILM, digital matte artist Paul Huston – who helped create the virtual landscapes for the Tatooine podrace course – utilized the animatics directly to produce many of the movie's final photoreal podrace shots.



The planet-spanning megalopolis of Coruscant – seat of government for the galactic republic – as visualized in a concept drawing by Doug Chiang.



To determine choreography and pacing of the effects and action sequences, much of the film was previsualized with sophisticated low-rez animatics created expeditiously by animatics supervisor David Dozoretz and his team.



To determine choreography and pacing of the effects and action sequences, much of the film was previsualized with sophisticated low-rez animatics created expeditiously by animatics supervisor David Dozoretz and his team.

In a possible foreshadowing of future produc-tion techniques, the pre-viz team contributed one hundred final shots as well, accomplishing what once represented a good-sized effects show in toto, within six months, with a crew of only four. That effort, which extended well beyond the unit's preconceived duties, had that foursome assembling elements, working with unit supervisors, and outputting film-resolution finals on Macintosh workstations as opposed to high-end machines. "ILM was doing phenomenal work," remarked Dozoretz, "but there was so much of it. I had a team of really talented artists working for me, so Rick decided to see how far we could push the 'garage visual effects company' model. It worked. Some of our shots included removing the C-3PO puppeteer or adding energy blades to lightsaber battles."

To determine choreography and pacing of the effects and action sequences, much of the film was previsualized with sophisticated low-rez animatics created expeditiously by animatics supervisor David Dozoretz and his team.

As the production moved into its final months, both the concept art department, which had been working for four years, and the animatics department, which had been working for three, began to wind down. It had been an arduous, but immensely rewarding time for all of the participants – most of them Star Wars fans who had relished the opportunity to be ushered into the select fraternity of explorers and creators of its fantasy worlds.

"I was raised on the original Star Wars," Jay Shuster reflected, "and consider myself a student of the aesthetic. Way back then, it was just George Lucas, an art department, ILM and a small model shop. Now it is this huge franchise – a production with thousands of people working on it. But one of the torches I carried into this project was to maintain the fragile grass-roots nature of that original endeavor – its home-brew quality. And I believe everyone in our group felt the same way. This was not just another movie, but a continuation of a grand tradition."

HEROES' JOURNEY

image

ARTICLE BY JODY DUNCAN
Kevin H. Martin
Mark Cotta Vaz

Sixteen years after ending the original Star Wars trilogy, creator George Lucas and Industrial Light & Magic delivered the first of its long-promised prequels. In Star Wars Episode I: The Phantom Menace, Obi-Wan Kenobi (Ewan McGregor) serves as apprentice to Jedi knight Qui-Gon Jinn (Liam Neeson). Sent to negotiate a dispute between the Trade Federation and the planet of Naboo, master and pupil team up with Gungan outcast Jar Jar Binks – an entirely computer generated character.

The Phantom Menace would be populated with more CG characters than any film in history. Maquettes were sculpted for major players, then scanned to provide the basis for computer models. Modelmaker Mark Siegel sculpts Watto, a flying alien introduced on Tatooine.

In the days of movie serials, audiences would leave theaters in a heightened state of anticipation, a state engendered by a cliffhanger ending and by the promise of resolution in the following week's installment. For sixteen years, fans of the orig-inal Star Wars trilogy have been in a similar frame of mind – except, in this case, the question was not, "How does it end?" but rather, "How did it begin?"

All creature concepts – plus most vehicles and settings – originated in design director Doug Chiang's department. Chiang studies Siegel's in-progress sculpture of a kaadu, one of the film's beasts of burden.

From the first moments of Star Wars: A New Hope, it was evident that the narrative was picking up not at the beginning of a story, but at its middle. A sense of history, of a struggle long in progress, endowed every frame of the film and its successors, The Empire Strikes Back and Return of the Jedi. What went before was a mystery; and even as the final movie in that original trilogy came to a victorious close, even as end credits rolled, countless questions lingered. What terrible events had transformed Luke's father, Anakin Skywalker, from a Jedi knight in-to the evil Sith lord, Darth Vader? Why had he turned to the dark side? What had started the fierce war between the evil empire and the galactic republic? How had the empire been born? How was the resistance launched, and by whom?

With the release of Star Wars Episode I: The Phantom Menace, some of the questions surrounding the saga's origins are finally being answered. That there would be another trilogy of films to tell that backstory was never in question. Star Wars creator George Lucas had promised from the beginning that Episodes I, II and III would follow production of the original IV, V and VI – he had just never said when those first three chapters would be made. As years passed and Lucas remained vague on the subject, more than one Star Wars devotee was left to wonder, "What is he waiting for?"

What he was waiting for, in fact, was the development of visual effects technologies that would allow him to realize, without compromise, the films he had always imagined. Frustration with the laborious and achingly slow filmmaking process in general, and with visual effects technology in particular, had plagued Lucas throughout the making of the original trilogy; and even though those films had possessed visual effects work that was nothing less than spectacular for its time, all three were, in Lucas' mind, shadows of the films he had really wanted to make. Until the technology had evolved to a point where his vision could be realized in totality, the director was content to put the new Star Wars trilogy on the back burner and concentrate his energies on other projects. Lucas would wait.

But in the interim, the entrepreneurial filmmaker had hardly been a passive observer of visual effects trends and technologies – he was, in fact, the field's most ardent, most aggressive promoter. As early as the late seventies – when the film industry, for the most part, was still contentedly working in the realm of photochemistry – Lucas developed a small in-house digital department at Industrial Light & Magic, his venerated visual effects facility, and encouraged that handful of computer wizards to stretch the envelope of digital effects for feature films, both artistically and technologically.

For the next two decades, Lucas kept his foot firmly planted at the backside of CG development – and the result was a dig-ital department that grew exponentially. Computer artists and workstations soon took over most of the square footage of the ever-expanding ILMfacility, setting the standard for digital effects in the process. First came Young Sherlock Holmes and its computer animated stained-glass man; then came the watery pseudopod of The Abyss. As major strides were made in the field, ILM went on to produce Terminator 2's liquid metal man; then, astonishingly, the dinosaurs of Jurassic Park, the dragon in Dragonheart, the ghostly apparitions of Casper and the even more photorealistic dinosaurs in The Lost World. The 'special edition' updates of the Star Wars trilogy pushed the learning curve even further and served as a kind of unofficial testing ground for Episodes I, II and III. Finally, Lucas felt confident that digital technology had evolved to a point where the making of his new Star Wars films was feasible.

Every morsel of that past experience would be drawn upon to pull off The Phantom Menace, a film of such tremendous scope it would dwarf every other 'big' effects film ever made. Of the movie's two-thousand-some shots, nineteen hundred would be either entirely generated or substantially enhanced through visual effects. So huge was the undertaking, so mind-boggling in complexity, that one half of ILM's entire work force of nearly twelve hundred people were dedicated, at one point or another, to the assignment; and the effort would consume much of the company's resources for more than three years. In addition, not one, but three of ILM's most accomplished effects super- visors – John Knoll, Dennis Muren and Scott Squires – would be called upon to spearhead the work.

First on the show was John Knoll, who was responsible for producing more than a thousand of the movie's effects shots – making his unit's contribution alone the largest digital visual effects project ever undertaken. Among Knoll's duties on The Phantom Menace was to establish and oversee an independent 'rebel unit' within ILM to create effects cuts for The Phantom Menace's space scenes, just as he had done for the Star Wars special edition. Working quickly and efficiently on lower-end computers, this rebel crew would create elements outside the traditional ILM pipeline, handling hard-surface animation, rendering and compositing on its own, and functioning as a self-contained unit. "Our stable of rebel unit artists was well versed in everything from modeling to texturing," remarked rebel unit supervisor Stu Maschwitz. "We would have one artist take a shot straight through from inception to completion, without separate pipeline phases for compositing and rendering. Everything was integrated in more of an artist-based approach."

Knoll was also ILM's on-set presence during principal photography at Leavesden Studios, outside of London. Lucas and producer Rick McCallum had selected Leavesden – a converted

Rolls-Royce factory refurbished by Eon Productions for the 007 feature Goldeneye – to afford the production a large measure of flexibility in scheduling. With a two-year lease on the facil-ity, The Phantom Menace could afford to leave sets up for a full year after principal photography wrapped, allowing Lucas to review his initial cut, determine what shots and scenes were still needed, then go back and do quick and inexpensive pickups months later. The scant sixty-five-day shooting schedule would take the production from Leavesden to Tunisia – which, as it had on A New Hope, would stand in for the dusty desert planet of Tatooine – as well as Caserta Palace in Italy for scenes taking place on Naboo.

The main on-set concern for Knoll was the shooting of live-action plates into which literally hundreds of digital characters and sets would be inserted. To a greater extent than any previous film, The Phantom Menace would employ a 'digital backlot' approach – meaning that actors would be shot on minimal sets or no set at all, in front of bluescreens, with digital set extensions added in post. To assure those plates would be suitable to the digital work that would follow, Knoll and a small ILM contingent took exacting measurements during the shoot. On-set matchmovers utilized a laptop computer connected to an electronic transit surveying system to record and convert data into coordinates that could be fed into CG software – a setup first developed by Scott Squires for Dragonheart. For further reference, Knoll shot lighting-sphere passes whenever possible. The sphere – with one side chromed and the other painted neutral gray – reflected the position of the stage lighting units and allowed key-to-fill ratios to be measured, providing the ILM postproduction staff with a better picture of what had transpired on set. In some cases, maquettes of digital characters were moved through frame for lighting reference data.

With many plate shots requiring extra passes for blank plates and lighting reference, on-set motion control seemed a likely approach; however, it was ruled out by Lucas early on. "There were a number of scenes that we needed to shoot more than once with the same move," said Knoll. "But George was really opposed to motion control, because although we've been able to bring it in and shoot quickly on other pictures, he felt it would make this show grind to a halt. So I just had to deal with it, trying whenever possible to get clean passes for shots featuring elements that had to separate out."

Principal photography had long been completed by the time Dennis Muren came aboard The Phantom Menace. Muren was unique among the three visual effects supervisors in that he had essentially started his feature film effects career working on Star Wars, then on Empire Strikes Back and, finally, Return of the Jedi, earning Oscars for the latter two groundbreaking films. Twenty years after embarking on that nine-year filmmaking odyssey, Muren was once again in the thick of the Star Wars universe. "As I looked at The Phantom Menace," Muren recalled, "there were a couple of sequences I really liked. One was the underwater sequence, and another was the end battle between the Gungans and the droids. What I liked about them was that both of those sequences were essentially all synthetic." With John Knoll's unit tackling approximately one thousand shots, and Scott Squires' team handling some five hundred, Muren's slate of three hundred shots was the most modest of the three assignments quantity-wise – but what it lacked in size it more than made up for in complexity. "Between the underwater sequence and the ground battle, there were a lot of challenges to deal with –

character animation and synthetic environments and outdoor settings. That appealed to me." Also assigned to Muren's unit were segments leading up to the underwater and ground battle sequences: an early swamp sequence as Trade Federation forces begin to descend on Naboo, for example, and a later scene at a sacred Gungan site.

By the time Muren turned his full attention to The Phantom Menace, in August 1997, Lucas and the art department at Skywalker Ranch, led by design director Doug Chiang, had been developing shots – through storyboards and animatics – for more than a year. Stepping in to execute predetermined imagery was atypical for Muren, who often had a strong hand in designing his effects shots. "Most of the shot design work had already been done or was being done by the time I came on," Muren affirmed. "So, at first, I backed off that process. But once they were done, George gave me the opportunity to change the animatics as I saw fit. He was really great about that, in fact. He encouraged me to discard the animatics, if I wanted to, and approach the shots fresh. So that's what I did for some of them – threw out the animatics and started over, trying to make them more cinematic, more dynamic, while still in keeping with the story George was telling."

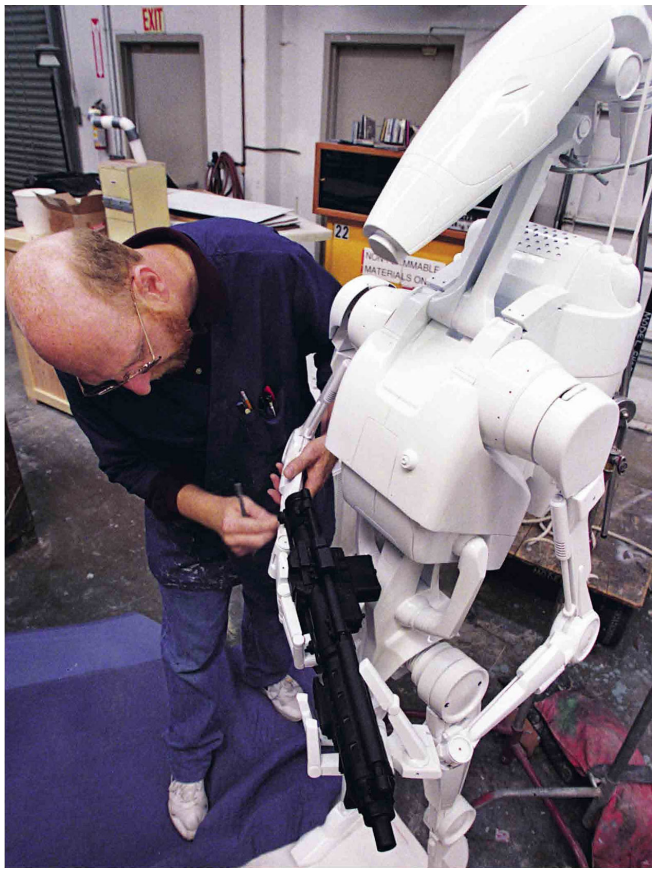
Last to join the production was Scott Squires, responsible for The Phantom Menace's breakthrough digital backlot and set extension shots, plus other effects, all executed at a level of sophistication never before attempted. "We made real inroads with things like the virtual backlot and blending CG environments with live-action sets," stated Squires, whose own breakthrough work included supervising creation of the magical CG dragon in Dragonheart. "We'd built bits and pieces of virtual sets in the past, but never on this scale. Also, because of the number of effects shots, this film was the equivalent of doing ten movies – and that volume in itself was new territory."

Although time was a factor for all units, it was particularly pressing for Squires' team, which began in January 1998. "We were the last unit to come onto the show," noted unit producer Heather Smith. "Most shows have a slow ramp-up period – an R&D time – but we had to hit the ground running." The team's work would include shots on Coruscant featuring an assembly of the galactic senate and a session in the Jedi temple, and – most prominently – shots centered in Theed, the exotic capital city of Naboo. From breathtaking flyover views, the unit would descend to the palace courtyard and penetrate the inner sanctum to the central hangar, move into a labyrinthine circuit of palace hallways, and arrive at the generator room for a climactic lightsaber duel. By itself, the Squires unit would complete 560 effects shots – more than the total number contained in most big-budget effects films.

The huge shot count was only half the challenge, however. The other half was the daunting complexity of scenes, which necessitated new production techniques. Organizationally, sequence supervisors and teams of technical directors handled individual sequences. Each unit was also assigned a CG supervisor: Tom Hutchinson for the Muren unit, Barry Armour for the Squires unit and Doug Smythe for the Knoll unit, with Kevin Rafferty acting as overall CGsupervisor and liaison between all three units. Rafferty was also instrumental in helping lay down the production pipeline that would facilitate the sharing of tools and personnel among those disparate units.

The level of difficulty and sheer volume of effects required that every aspect of the ILM production process be evaluated and, if possible, updated and streamlined – a formidable task that kept the sixteen-member software R&D group hustling from the first day of preproduction to the last day of post. “Usually a show will have one or two R&D challenges,” visual effects producer Judith Weaver stated, “but this show had about two dozen such projects.”

While the R&D group, headed by Christian Rouet, often purchased commercial product and modified it for use with ILM’s existing mix of off-the-shelf and proprietary software, new in-house product would be created as needed when the requisite level of performance could not be attained through existing packages. Before new R&D projects could be incorporated into the existing pipeline, however, a facility-wide upgrade was required to streamline job scheduling, memory allocation and frame rendering. “While the project of optimizing computing resources was not a visible part of the Star Wars iceberg,” observed Rouet, “it was very important to the overall show, and required a third of our total resources to realize fully.” Instrumental in executing the comprehensive upgrade was software developer Florian Kainz. “There were enormous numbers of people and computers added for this show,” Kainz explained, “so we built a system that supported the increased processing load and ensured that overnight rendering continued even if individual computers or parts of the network failed.”

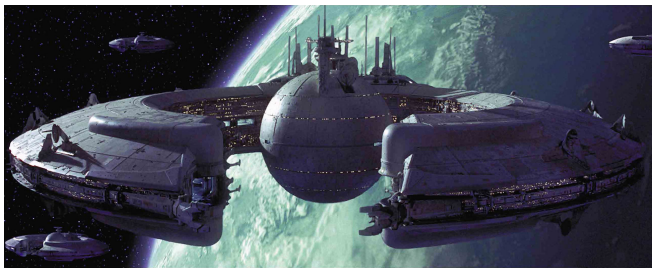


Featuring nearly two thousand visual effects shots, The Phantom Menace would be the largest and most ambitious effects film ever realized, combining huge volumes of digital imagery with extensive photographic elements and miniature sets. Central to the storyline is the Trade Federation invasion of Naboo by its army of droid soldiers. Though the masses of battle droids would be created digitally, the model shop provided full-scale versions to develop the look of the computer model and for use as on-set lighting reference and set dressing. Model shop supervisor Steve Gawley assembles a full-size battle droid, one of more than five hundred model projects – from ground and space vehicles to miniature sets – built practically for the film.

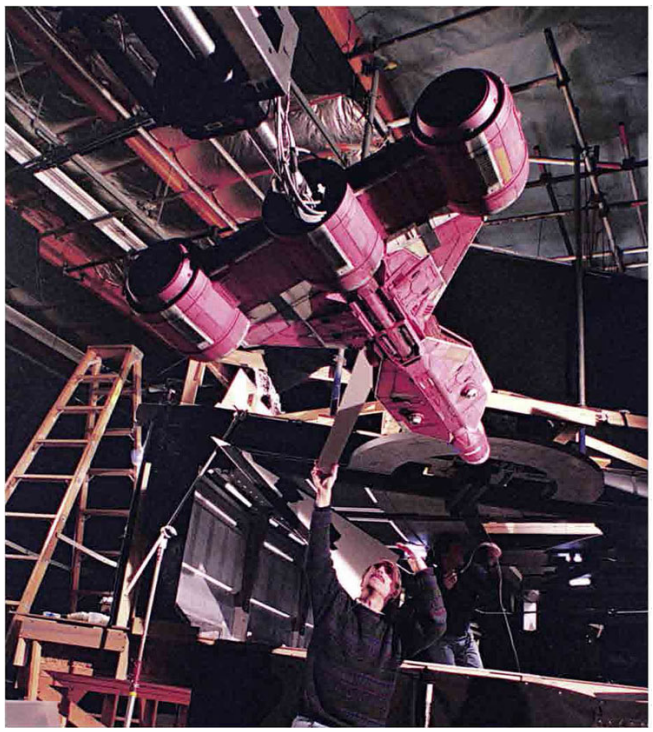
New hardware included an updated scanner, built in-house, to supplant an existing one that had been in use for a number of years – a necessity since the entire movie would have to be scanned before entering ILM's system. "One of the things we'd been hammering on for years was improving scan speeds," said scan supervisor Joshua Pines. "We improved the overall performance by a factor of three to five – and there remains potential for even faster performance." Software developer Rod G. Bogart worked with Pines to write multiprocessing control software for the improved scanner. With a second unit also fabricated and brought on line, the two new scanners processed images at rates that topped out at twenty thousand frames per week during peak months of production.

Software, hardware, personnel and the overall pipeline were securely in place by the time effects production commenced in earnest, early in 1997.

ACT 1

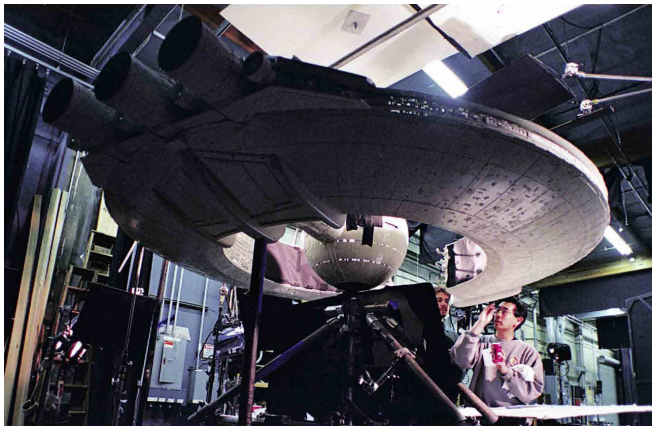


Impending invasion is signaled by the presence of huge Federation battleships orbiting over Naboo. Multiple ships were represented by a single eight-foot-diameter miniature – filmed motion control against bluescreen – while the view of the planet from space was realized via 2D artwork applied to 3D geometry.



The Jedi peace negotiators arrive at the lead battleship on board a Republic space cruiser. Positioned for its approach to an enlarged section of the battleship's docking bay, the seven-foot cruiser model is readied for a motion control pass by director of miniature photography Pat Sweeney.

In the Star Wars tradition, The Phantom Menace opens with a vast starfield, through which a legend scrolls informing us that a trade dispute has erupted between the powerful Trade Federation and the small, peaceful, outlying planet of Naboo. The dispute has escalated with the Federation's shipping blockade of Naboo, and the Republic has sent Jedi knight Qui-Gon Jinn (Liam Neeson) and his young apprentice Obi-Wan Kenobi (Ewan McGregor) to negotiate.



The battleship miniature is inspected by modelmakers Grant Imahara and Tori Bellici prior to a shot.

As the legend trails away, a Republic space cruiser carrying the Jedi is seen approaching Naboo, currently surrounded by Neimoidian battleships. The cruiser docks with the lead battleship and the Jedi disembark to pursue their mission. Though most spaceships seen in the movie would be digital creations, the opening six-shot sequence featuring the cruiser and battleships used only practical models, shot motion control against bluescreen on the ILM stage. In addition to motion control and pyrotechnic use, miniatures would also be employed for scanning purposes to aid in the creation of digital craft and droids. "John Knoll is an especially strong believer in building models to serve as reference for shapes, lighting and paint schemes," stated model shop supervisor and original Star Wars alumnus Steve Gawley. "That approach solves a number of important questions for the digital crew, and eliminates most, if not all, design issues."

Rumors preceding the release of The Phantom Menace had suggested that practical models would be all but nonexistent in the computer graphics extravaganza; but, in reality, the ILM model shop team faced its biggest assignment ever. "We built one hundred model projects, and there were multiple models required for each," commented Gawley. "In total, we built five-hundred-plus models, miniature sets and characters for this show. We employed as many as eighty-seven modelmakers at a time, with an average of sixty for a full year. It was huge."

The circular Federation battleship model – which from certain angles resembled a donut with a bite out of it – measured eight feet across, with forward-facing lateral wing-shapes that were removable for close shots of the command sphere at its center. This necessitated plugs that made sections of the ship self-contained electrically, a serious consideration given the large number of tiny lights on the vessel that helped convey a star-destroyer-like mass. The many battleships appearing over Naboo in the course of the story were assembled from motion control photographic elements shot by director of miniature photography Pat Sweeney, with a single battleship model used to represent every element of the enormous fleet.

Two- and three-dimensional techniques were combined to create planets as seen from space – such as the view of Naboo from the Federation battleship. "Brian Flora painted textures that wrapped onto a sphere for shots of Naboo," explained John Knoll. "Pieces of this imagery were rendered out and brought into Photoshop for additional paint work. Then we took these

beautiful high-rez 2D images and mapped them back onto 3D spheres – which gave us a bit of perspective change, through either camera movement or planet rotation."

Stylistically reminiscent of the rebel blockade runner in the original Star Wars, the seven-foot Republic cruiser, like most of the other spaceship models built either for scanning or for on-screen duty, was patterned in wood, with detail parts generated in silicone epoxy. Gawley's crew also constructed a miniature set representing the first two hundred feet of the battleship's hangar interior for shots of the Jedi cruiser moored within. A still photograph taken of the hangar model from the appropriate angle was subsequently inserted into the open end of the exterior battleship miniature, establishing a visual connection bridging space exteriors and vessel interiors.

After disembarking from their ship, the two Jedi are led to a conference room, where they await the arrival of Trade Federation representatives. The Neimoidian trade viceroys aboard the battleship were initially slated to be computer generated characters, and their original designs could not have been implemented by any other means. Shortly before the movie went into production, however, the filmmakers determined that this was one place where the effects budget could be trimmed, and the designs were modified to accommodate actors in animatronic heads, created by Nick Dudman's creature crew.

The darker motives and loyalties of the battleship crew are revealed as Sith lord Darth Sidious – appearing in holographic form – instructs the Neimoidians to kill the Jedi on board. The look of the holograms had been as well-established in the Star Wars universe as the sound of a lightsaber igniting; and so, for The Phantom Menace, their creation anew was simply a matter of emulating what had gone before, but through digital means. 2D image processing was used, with signal noise introduced to create interference patterns lacing the holographic image.

In response to Sidious' order, a turreted gun in the battleship docking bay opens fire on the parked space cruiser, which immediately explodes. The destruction of the vessel fell to pyrotechnician Geoff Heron and his crew, who provided all three visual effects units with custom blasts over the span of a nine-month shoot. "The Republic cruiser was a stand-alone model pyro shoot within the full miniature set," Heron remarked. "By shooting it with the miniature, the exploding ship pieces could interact with the docking bay walls and deck, so no extraction was necessary – an approach we favored whenever possible."

When the Neimoidians learn that the Jedi are still on board the battleship, battle and destroyer droids are ordered to hunt them down and kill them. The droids were among the hundreds of 'hard-surface' computer models built for the film, and were based on Doug Chiang designs sculpted as sixth- and eighth-scale maquettes by John Goodson and John Duncan, then made up into full-size versions for use as on-set reference. "The look of the droids, the paint scheme, all of that was worked out on the full-size versions," observed

On the battleship bridge, Neimoidian representatives converse with the mysterious Sith lord Darth Sidious, who appears in hologram form to order the deaths of the Jedi knights. The holographic look established in the early films was replicated for The Phantom Menace, although

Gawley, “which were about six feet, six inches tall. We also built a destroyer droid, already in its ‘unfolded’ configuration. We used epoxy lay-up for both.”

digital rather than optical techniques were employed to create the images.

A squad of battle droids is dispatched to hunt down Qui-Gon and Obi-Wan? A special ‘hard-surface’ digital team worked independently of the creature group to model, animate and render droids, spaceships. weapons and tanks. Among the innovations at ILM – which, in terms of digital animation, had previously dealt almost exclusively with organic creatures – were new painting and modeling tools that facilitated the creation of these inorganic hardware models.

Hard-surface models included not only the droids, but also spaceships, podracers, landspeeders, speeder bikes, tanks and any other mechanical animated object. The building and painting of such models would prove to be one of the breakthrough efforts on The Phantom Menace. “Prior to this film,” related on-set matchmover and digital modeler Jack Haye, “most of ILM’s CG modeling had been related to creatures. As a result, we had only a few tools designed specifically for making hard-surface models. As recently as two years ago, we were using techniques based on our old creature-building technologies. For this show, we had to have new techniques that would allow us more freedom in modeling.”

That freedom came as a result of tools that allowed the modelers to mix and match both polygonal and spline-based forms. “Many of the hard-surface models in this show were not one-hundred-percent spline,” stated senior digital modeler Russell Paul. “A model that was relatively simple could be built out of polygons – and sometimes it was best to do it that way. Other times, it was best to stick with splines. We learned a lot on this picture about where we could use what technique to build the type of models we wanted.”

New viewpaint software – the 3D paint system developed at ILM for Jurassic Park – also optimized the final look of the CG models. The R&D effort to update the viewpaint system was undertaken by David Benson, Eric Schafer and Alan Trombla, who together came up with a paint package – Irender – that accommodated polygonal models and new techniques for texturing hard-surface models. “The new paint system afforded a simpler means of looking at the construction and painting of models,” said digital modeler Colie Wertz, “creating greater freedom in the modeling process.”

Digital modeler Simon Cheung was responsible for the battle droid, while Jack Haye and Russell Paul modeled the digital destroyer droid, which, with its variable geometry, could unroll from a spherical configuration into a tripodal base to form a menacing, insect-like shape. “All together, there were nine different types of droids modeled by the hard-surface crew,” said digital model supervisor Geoff Campbell. “We started by looking at the storyboards so we could see what needed to be built for a long shot, a medium shot and a closeup. We also looked at the duration of a shot to determine whether it would require a quick one-off model or something more elaborate. We needed to know the layout of each shot to determine how detailed we had to get with each model. Some of the more distant models were built very low-resolution – in some cases, just cards with projection-mapped detail.”

Just as a separate crew would be responsible for modeling such hard-surface creations, a special hard-surface animation team worked independently of the character animation group, which would provide the performances of literally hundreds of computer generated characters. “A character shot was defined as any live, breathing, possibly talking character,” stated

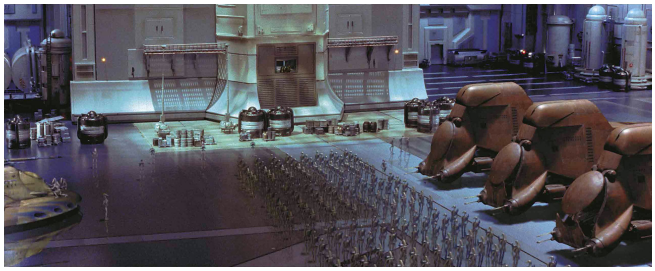
animation director Rob Coleman, who would oversee the creation of eight hundred character animation shots. “Another group of animators took care of non-character shots, such as the vehicles in the podrace and the spaceships. Then there were hybrid shots where both teams were involved. In the podrace, for example, my team animated the driver characters, while the other team took care of the vehicles.”

Animation of the battle droids was inspired by George Lucas’ view of the machines as somewhat birdlike, exhibiting flocking behaviors. “George explained that the battle droids were early versions of the Imperial stormtroopers that hadn’t worked out too well,” recalled Coleman. “Stormtroopers were able to think and act on their own; but the battle droids receive information and direction from the battleship, so they act as a unit – and there’s a bit of a delay in their reactions. They are, to some degree, incompetent. They don’t seem able to hit the broad side of a barn with their laser blasters, for example. The idea was that their sheer numbers would overwhelm any enemy – but they do not make the most efficient army. George always said, ‘That’s why we see stormtroopers in the later films – these guys didn’t make it.’ So the battle droids had to be both scary and funny, which made them very difficult to animate.”

Unlike the mindless, automaton-like battle droids, destroyer droids are both lethal and fast, rolling into position, then popping open into their tripod configuration and firing. “Because the destroyer droids were three-legged,” said Coleman, “it took a while to come up with a walk cycle that looked right. We animated them to walk like spindly, three-legged spiders, but still made them look very mechanical and menacing.” The lethal characteristics of the destroyer droid were also suggested via its paint scheme, which had a burnt-oil color and interesting specular highlights.

In rendering and compositing the droids, sequence supervisor Curt Miyashiro often worked from set plates featuring a full-size droid maquette, used for lighting reference and as an aid to the digital modelers. Even so, the reference material was not always dead-on accurate, and the lighting of the final CG version had to be tweaked considerably. “The cinematographer lit the maquettes as well as possible,” related Miyashiro, “but we always had to add lights to get the flourishes that would make them look great. A shiny chrome look is hard to achieve with the kind of lighting used on these interiors; and that lighting also made it difficult to create highlights.”

Severely outnumbered, the Jedi retreat from the advancing droids, inflicting casualties in the process. “Droids falling prey to lasers or lightsabers were augmented by special models that exploded to expose interiors that were partly modeled with additional geometry,” remarked Miyashiro, “though much of the additional detail and unique droid flourishes came courtesy of the viewpainters.”



To escape their robotic pursuers, Qui-Gon and Obi-Wan hide in a ventilation shaft overlooking the massive battleship hangar where droids and tanks are being loaded into landing craft in preparation for the invasion of Naboo. Computer generated landing ships, tanks and battle droids were composited into a miniature hangar set that was

The skirmish ends with the Jedi hiding in the hangar venti-lation shaft, where they witness

battle droids and tanks being loaded onto landing craft headed for the surface of Naboo. For close views within the hangar, the model shop built a single eight-foot lander model, while CG versions – modeled by Shadi Almassizadeh – were constructed for views of the entire squadron, both within the hangar and in space above the planet.

Closeup views of the parked landing ships were obtained with an eight-foot practical lander model, shot within the miniature hangar set. Modelmaker Foh Davis details the craft.

Qui-Gon and Obi-Wan stow away on one of the giant ships that deploy from the hangar and fly in formation toward Naboo, putting down on the planet's marshy surface. While John Knoll's unit produced all the space shots of the landing ships, Dennis Muren's team picked up the action at ground level, utilizing the physical model. "The first thing we did for Dennis," remarked director of miniature photography Pat Sweeney, "was a plate showing Naboo from above – a giant, tree-filled planet. We had one landing craft model; and with that model we did a move of the foreground ship flying into frame from behind camera, then landing and descending into the trees – a motion control move, shot in front of bluescreen. The planet surface was just a photograph taken into Photoshop and tricked out to make it look more exotic – which was done for a lot of the landing craft backgrounds."

As the foreground craft lands, the camera pans over to another already on the ground. Its doors open and tanks emerge. These tanks – both MTTs, mobile troop transports, and AATs, armored attack tanks – are dispatched from the landing craft and begin to roll through the wooded Naboo landscape. Since the scale of the landing ship model was too small for a closeup of the emerging MTTs, the model shop built an oversized lander door section. Modelmaker John Forman constructed an elevator mechanism on the model that allowed it to lower a small-scale MTT inside as another in front was being pushed forward, out the door. "With the mechanism built into this oversize boot section of the landing craft," related Sweeney, "the MTT could come down a little ramp, but that was as far as the mechanism could take it. So Ray Gilberti shot a larger eighth-scale MTT that the model shop had built for other shots, and blended that model photography into the shot, showing the MTT in front coming out of the boot and moving out of frame."

The power of the tanks is demonstrated as they plow down hundred-foot-tall trees in their path. To get shots of the trees toppling, ILM made arrangements with a local power company responsible for removing trees endangering power lines. "They were going to cut them down anyway," noted visual effects producer Jeff Olson, "so Dennis came on location with us, and we filmed for a day as these very capable tree trimmers climbed and cut down hundred-foot-tall eucalyptus trees and dropped them into a field. We caught the whole process with multiple cameras." Those elements were used in conjunction with properly timed animated tanks, created by the hard-surface modeling and animation crews.

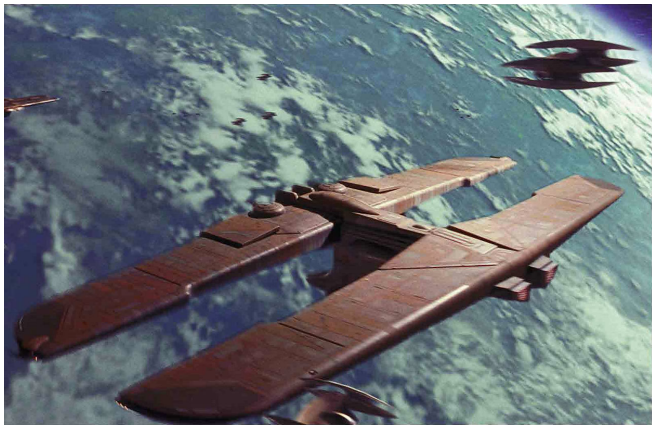
The thundering advance of the tanks instigates a stampede of whimsical animals – all done digitally. "We modeled about ten different creatures," said Geoff Campbell, "and cloned them to make up a whole army of stampeding animals. We didn't always get maquettes for them. Since they were only going to be seen briefly, in quick shots, there wasn't a lot of time or budget that

could be spent on them. So rather than scan a maquette to begin building them, we either built them from scratch or took bits and pieces of other models we already had on hand."

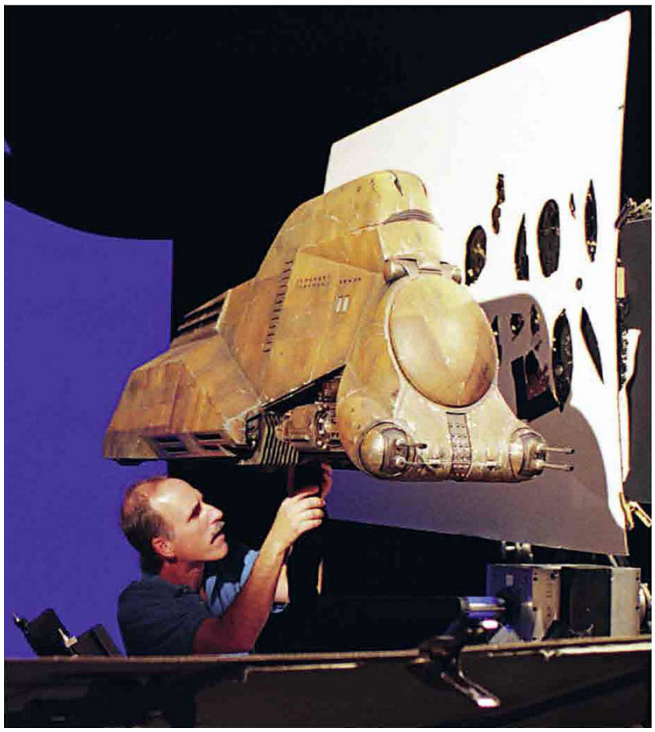
Though animation for individual creatures in the stampede could be recycled with only minor variations, a means of drawing paths through the forest and placing creatures on those paths was required. Choreographer, a program devised by Jim Hourihan, John Horn and Zoran Kacic-Alesic, permitted a var-iety of custom alterations to character animation movements and timings while attaching those characters to specific motion paths. Creatures could be slowed down or sped up on the desired paths, and modifications to the CG walk cycle – such as leaps or pauses – could be introduced before a cycle recommenced. Choreographer also allowed for previewing the animation of numerous characters simultaneously, in real time, with simplified versions that gave the animators an idea of how a given creature would look within a finished scene.

After making a stealthy departure from the landing ship, the Jedi are caught up in the stampede, with Qui-Gon being forced to outrun the oncoming MTTs. Bluescreen elements of Liam Neeson were composited with model photography of the tanks. "We put our model tanks into shots of the background with Qui-Gon running," explained Pat Sweeney. "Shot by shot, Dennis would specify what kind of scale he wanted and how many tanks he wanted. We played around and adjusted the scale and height of the tanks for each shot. The MTTs were supposed to be about twenty-five feet tall, but we would make them shorter or taller for the sake of better framing or for dramatic impact. In one shot where the MTT is supposed to look as if it is just about to run down Qui-Gon, we made the tank look huge."

Background environments for the Naboo swamp sequence were collaged together from a variety of still photo sources and composited using ILM's high-speed Saber system. "The visual effects supervisor could sit right next to me," Saber artist Chad Taylor noted, "and we could move things around interactively and try out different versions of shots very quickly. Saber has 3D, 2D, paint, roto, extraction capabilities – all integrated into one package." In particular, Dennis Muren and his unit's producer, Ned Gorman, took advantage of Saber's interactive qualities. "Initially we were slated to do simple, basic compositing; but Dennis and Ned realized we could do more. Dennis would sit down, look at a shot, and say, 'It isn't right.' In ten seconds I could change it, play around with it, re-render it – and there would be a new version right there for him to look at. Most of the time in CG, the supervisors look at dailies in the morning, make suggestions, and then won't see changes until that afternoon or the next morning. With Saber, the feedback was instantaneous." Saber ultimately would be involved, to some degree, with seven to eight hundred shots in The Phantom Menace.



Federation landing ships descend to the surface of Naboo. While most shots of the spacecraft, once landed, were captured with practical models, ships in space were produced digitally by a self-contained ‘rebel unit’ formed under the direction of visual effects supervisor John Knoll.



Ground vehicles such as the MTT – mobile troop transport – emerge from the spacecraft after they land. Pat Sweeney adjusts the mount on an MTT model prior to filming. Cut-outs between the lights and the model simulated the look of passing shadows as the tank plows through the Naboo forest.

As Qui-Gon attempts to outrun the MTT, he literally runs into a frightened Gungan, an amphibious species that lives largely underwater, in isolation from the human inhabitants of Naboo. Jar Jar Binks – outcast from the Gungan domain for the sin of clumsiness – promptly pledges lifelong loyalty to Qui-Gon, believing the Jedi knight has saved his life. Serving as both sidekick and comic relief – and featured throughout most of the film – Jar Jar would be the most expressive, complex computer generated character ever realized.

Qui-Gon meets Jar Jar Binks as both are caught up in a stampede of animals, prompted by the advance of the thundering tanks. Bluescreen footage of Liam Neeson was composited with digitally assembled backgrounds, tank model photography and computer generated elements of Jar Jar and the fleeing creatures.

“Jar Jar was the closest thing to animating a human character that we’d ever done,” Dennis Muren elaborated. “There had to be that kind of complexity in his performance – saying one thing, for example, when you can tell from his expression that he means something else. That sort of thing had to be there, all the way through the picture. The other thing was that he was acting right alongside all of these human characters, played by great actors, so he had to follow the rules of physics and not do anything too fantastic or unreal.”

In the design phase, Doug Chiang’s team had found Jar Jar to be the most difficult character to conceive, and the Evolution of his appearance continued through the modeling stage. Generally, once a design of a character was approved, Richard Miller and Mark Siegel sculpted a clay maquette that was then cast in plastic and scanned to serve as the starting point for the construction of the CG model. “We had in-house software that allowed us to get really detailed scans,” explained Geoff Campbell, “and from there we would create B-spline patches using Isurf, our proprietary software. Then we surfaced the model and worked up the detail. On some of these creatures, especially talking ones, there was a lot of detail work in the mouth, the gums, the teeth – and all of that had to be modeled by hand, using either Alias or Isculpt, our modeling software.”

In total, nearly a hundred creatures had to be modeled digitally for the show. While the maquette-scanning approach was typical, Jar Jar was fashioned from scratch, with the modeler utilizing only sketches as reference. “Jar Jar was the first creature model to be built,” commented Campbell, “and that was at an early stage, when the script was still being written. George liked the idea of fleshing out some of the characters in CG so that he could change things and remain very flexible. Rather than sign off on a maquette, the idea was to evolve the character by sculpting it in the computer. I started using Alias, then converted to Isculpt, in which I could manipulate as if it were clay. The beauty of Isculpt is that it allows you to make quick sculptural changes. I could sit down with George, show him the model-in-progress, then incorporate his changes and suggestions. He’d say, ‘What if the eyes are off the head and the nose is longer?’ – and I could pull and push it around to accommodate those suggestions. That’s how Jar Jar evolved.” The Jar Jar model also served as the basis for other Gungan characters in

the movie such as Boss Nass, Captain Tarpals and the Gungan army troops featured in the climactic ground battle.

Animation libraries were constructed for Jar Jar and all the other speaking CG models, both for facial expression and lip-sync purposes. “We created facial expressions as key shapes,” commented Campbell, “to establish a library for the animators. We delivered to the animators a package with these shapes and sliders and other controls so they could dial in shapes to create facial expressions. Facial expression libraries were also set up for nonspeaking characters.” Jar Jar’s horse-like muzzle made the formation of lip-sync positions extremely difficult. “We set up phonemes, starting with the vowels and then going into consonants to work out a pattern of speech for each of these characters. But for Jar Jar, it was quite a challenge to figure out how to make the facial shapes believable. It was hard to make lip-sync shapes that didn’t look cartoony.”

Another element of the design that made Jar Jar’s lip-sync difficult was that his upper ‘lip’ was shaped like a duck’s bill. “We kept trying to determine what that was made of,” recalled Campbell. “Was it flesh? Was it cartilage? What it was made of would have a big impact on the lip-sync. For example, if it were hard cartilage, how could he bring that top ‘lip’ down to the bottom to form an ‘M’? In the end, we made it more fleshy so we could curl the lip underneath and create mouth shapes that made sense.” Lucas also requested that Jar Jar have a characteristic smile. In the seminal stage of modeling, the smile was attempted by pulling the Gungan’s teeth and gums and mouth out to the side of his head. “It was an offset, ‘Tex Avery’ kind of smile, but it didn’t work because it wasn’t grounded in the real world. As George saw these changes, he decided to pull back, taking the character out of the realm of cartoon and more into the realm of reality.”

The tool employed to create facial expressions and lip-sync positions was Caricature, ILM’s proprietary character animation system – for which designer Cary Phillips earned recent recognition from the Academy of Motion Picture Arts and Sciences. Cari had been in use for some time, but had to undergo an overhaul for The Phantom Menace. “Our last show featuring heavy-duty facial animation was Dragonheart,” said Phillips, “which was several years ago. For this show, we needed to do things in a more sophisticated way, so I revised the animation controls to handle multiple creatures in conversation, for example. This restructuring allowed for the management of many individual elements of facial movements – which we identify as ‘shapes.’ On any given frame, there can be many such shapes – ranging from lip curls to individual vowel-sound positions – contributing to each creature’s facial animation.”

When the Jar Jar computer model was completed, it was sent to the chaining and enveloping departments where it was prepared for Rob Coleman and his character animation team. The enveloping process – which defines the influence various body joints have on regions of skin stretching over a digital skeleton – also underwent major renovation. “Our previous version was very powerful, but took a long time to learn,” admitted Phillips. “Developing an envelope and setting up parameters was very time-consuming – and since much of that time got lumped at the beginning of the process, it was a long while before an enveloper could show anything to his or her supervisor.” The new tool – Carienv – was created by software developer Vishwa Ranjan,

and rolled right into Caricature. “Carienv’s graphical interface succeeded in making the process much more interactive. It also required less in the way of technical knowledge.”

The animation of Jar Jar would be based on the physical and vocal performance of actor Ahmed Best. Throughout principal photography, Best – wearing a Jar Jar suit constructed by Nick Dudman’s creature crew – played the live-action counterpart of the computer generated character. Scenes between Jar Jar and the other actors would be filmed with Best on camera, allowing the actors to work out interactions and timings with the character – a far better acting situation than trying to perform with a nonexistent Jar Jar. Typically, once the scene was worked out to Lucas’ satisfaction, production takes would be filmed with Best out of frame. In some instances, however, Lucas preferred the performances in the rehearsal takes that included Best. As a result, ILM’s digital rotoscope department – under supervisor Susan Kelly – was faced with a number of ‘Ahmed-Best-removal’ shots to produce a clean plate into which the CGJar Jar could be composited.

Initially, Lucas had contemplated computer generating only Jar Jar’s head, which would then be matchmoved and attached to Best’s body. Toward that end, the performer wore the Jar Jar suit, along with a prosthetic head piece – placed on top of his own head to denote the appropriate height for the character. The notion was to retain the live-action footage of Best up to his neck, then replace everything above the neck with CG. “The original thought was that it was going to be much too expensive to do every single Jar Jar shot entirely as CG,” commented Rob Coleman. “So they invested the money into building the suit, and we were only going to do the head replacements. One of my first jobs when I came on the show was to do a test of that idea with a team of animators. We quickly realized that the CG head replacement was not going to be as easy as we thought. There were serious problems with things crossing in front of other things, meaning that some things had to be painted out and others had to be put back in. The biggest problem, though, was the fact that as wonderful as Ahmed’s performance was, his anatomy was not the same as Jar Jar’s anatomy. My main concern was that if we did some of the shots with Jar Jar entirely CG – which we were going to have to do for some of the more extreme, Gungan-like moves – and others with him part-CG and part-Ahmed, they weren’t going to cut together well at all. So I presented the work to George and brought up these points; and before we even started production, the decision was made to create Jar Jar entirely through CG. The only shots in the film with Ahmed as Jar Jar are those in which you see an arm or foot or part of a knee in the edge of frame.”

Though that decision freed Jar Jar lead animator Lou Dellarosa and his team from the physical limitations of a real live actor, Best’s performance was still the model for ninety percent of Jar Jar’s animation. “There were shots where we literally followed Ahmed’s actions frame by frame,” acknowledged Coleman. “So Ahmed’s performance is certainly there, even though his body isn’t. Ahmed created this character.”

While the animation of Jar Jar and other prominent CG characters was principally a performance issue, their clothing was a technical one. Having dealt primarily with the computer animation of unclothed animals, the ILM team had seldom come face to face with the difficulties of animating the dynamics of fabric as it moved and flowed on a CG character’s form. It was, in fact, an issue that had plagued the entire CG world for years. “The kinds of cloth simulations

seen in off-the-shelf packages tend to emulate thin cotton or lightweight silk materials," said Doug Smythe, "but for this show, there were many heavy costumes and burlap-like materials – an altogether different proposition. For Jar Jar, his clothing was a two-tiered operation, one aspect being his bulky outerwear – made of heavy, leather-like material – and the other, his shirt and pants."

In the past, academics had tried to create a workable cloth simulation by dealing with CG cloth the same way one would deal with fabric in the real world – by cutting out patterns from flat pieces and joining them together. ILM's technique was to model the cloth in 3D in its 'at rest' position – that is, the form it would take when it was on a standing CG character – with 2D textures applied to give it the look of cloth. That cloth geom-etry would then be modeled into specific costumes, and would be driven by the animation of the CG character.

The procedural cloth simulation software was developed in-house by Jim Hourihan and John Anderson, working with Cary Phillips. "John has an amazing intuitive understanding of conceptual physics," said Hourihan, "which saved the day on this project. Cary and I developed the basis for simulation in our pipeline and a first pass at the cloth solver. John later reworked the solver and came up with physics that really captured the look of several different kinds of fabric."

Ultimately, the cloth simulation would be used not just for clothing but also for cords dangling off of characters, and even as a means of animating Jar Jar's floppy ears. This 'secondary animation' was overseen by Tim McLaughlin, who worked side by side with animators whose primary focus was performance. "The animators would work on the action," stated McLaughlin, "get that correct, and then I would work with them to get the rest of the animation done – all the stuff that moves as a result of the character moving. In a perfect world, an animator would only have to concern himself with the performance of a character, the actual acting; and from there, there would be an automatic procedure to deal with the secondary animation that is driven by the initial performance. There would be basic laws of physics in the virtual world that would always play out as they should. We are not there yet, but we're moving toward having those things happen automatically."

The final stop in the pipeline for Jar Jar was rendering and compositing – both complicated somewhat by the character's pronounced, bright coloring. "His skin color was such that he had some very light areas and some color areas that were very saturated," explained 2D composite supervisor Jon Alexander, "and depending on where the lights were, his light areas could be very, very bright. Within the composite, we'd pull different mattes for different areas to bring those down, leaving his more saturated areas as they were. There was no reason to re-render just to make that kind of color tweak – there was a lot we could do in the composite." Casting of shadows

As a principal character and the film's comic relief, Jar Jar Binks would be the most complex and most prominently featured CG character ever realized. To work out scenes between Jar Jar and the human cast members, as well as provide

onto Jar Jar from live characters within his proximity was also done in the composite stage. “Once we had all the elements together, we could see what the placement of the shadows should be. There are lighting and shadow touches that are much more difficult to deal with in the render – and there’s no point in doing them there when we can do them far more interactively in the composite. It’s a huge cheat, but it works and it’s efficient.”

animators with a reference performance, actor Ahmed Best portrayed Jar Jar on set. Best was then replaced by the digital character in final shots.

Animation director Rob Coleman oversaw the performances of all the film’s CG players and the generation of some eight hundred character animation shots. Libraries of facial expressions and lip-sync positions enabled animators to produce the large volume of shots expeditiously. At his workstation, Coleman reviews a shot of Jar Jar.

Creating a character as prominent, as complex, as alive as Jar Jar entirely through digital means had been one of George Lucas’ riskiest decisions – but in the end, his faith in ILM’s animation and technical direction teams was wholly justified. “At one point,” recalled Coleman, “George told me that, even after starting the show, he’d been very apprehensive about whether or not we were going to be able to pull off Jar Jar, but that we had surpassed his wildest expectations. That comment alleviated a lot of stress in my life.”

As the invasion of Naboo intensifies, Jar Jar suggests that the Jedi retreat to Otoh Gunga, the underwater city in which the Gungans dwell. The underwater sequence was the first assignment to be tackled by Dennis Muren, Ned Gorman and their crew. Work on the sequence had actually originated with chief modelmaker Giovanni Donovan in the ILM model shop, where twenty-four miniature sets were built to represent the canyons, tunnels and mountains of Naboo’s underwater terrain. The plan was to shoot these models motion control in a smoke-filled environment, then composite that stage photography with bluescreen elements of the actors and a CG submarine.

The underwater terrain sets were constructed out of heavy-gauge foil, then painted and texturized. “The biggest one,” said Steve Gawley, “was twenty feet tall, twenty-five feet wide and maybe forty feet long. The heavy-gauge foil was a very forgiving material because we could change it easily and recycle it.”

Jar Jar offers Qui-Gon and Obi-Wan refuge in Otoh Gunga, an underwater city comprised of transparent spheres supported by ornate ribs encasing each clustered module. Wide shots of the Gungan city were achieved via a digital set built by the hard-surface modeling team and enhanced with CG particulate matter and fish to suggest its watery surroundings.

Effects director of photography Marty Rosenberg filmed the completed sets in a smoke room on stage. “We shot about fifty underwater background environments in the course of eighty days,” related Rosenberg. “Often we were doing a shot a day.” Controlling the amount of smoke in the room was a daily challenge. Smoke would be pumped in, and the crew would then wait to shoot until it had settled appropriately. “We needed smoke that was absolutely motion-free. I used a small light in the corner of the stage to judge the smoke levels. Spot-meter-reading that light gave me the ability to reliably judge smoke density for shot-to-shot continuity. One of the keys to this was that we had climate control on the stage, so it could be kept at a particular temperature at all times. We also spent quite a bit of time at the beginning making the room airtight so that the smoke would just sit there.”

Inside the city, Qui-Gon implores Gungan leader Boss Nass to aid the people of Naboo against the Federation threat. Complex Gungan wardrobe – especially that of Boss Nass – required in-house development of sophisticated cloth simulation software.

One of the trickiest underwater sets to shoot was the long tunnel penetrated by a submarine carrying Qui-Gon, Obi-Wan and Jar Jar, seen later in the underwater sequence. The tunnel set was only three feet wide and two feet high, yet a whopping thirty feet long – dimensions that made photography particularly difficult. “We had to not only light that,” recalled Rosenberg, “but bring a camera through it – which was impossible. We ended up shooting that set in multiple passes, using a motion control camera. We could backwind the film, then run the camera through as many as four times.” With the set built in one-foot-wide removable sections, the camera crew was able to remove two-thirds of the wall pieces on the right side of the tunnel for the first pass. “Lights on dimmers were rigged and hidden behind the remaining one-third of wall on the right. These lights were focused on the opposite left wall as we shot the left side. Then we’d switch all the wall pieces and shoot the other side. Finally, we’d replace the tunnel pieces and shoot a ‘fill’ light pass with a specially built light on the camera.”

Visual effects supervisor Dennis Muren and Doug Chiang inspect models of the sphere-city’s structural rib supports – which, like most of the Gungan designs, drew extensively from art nouveau influences.

As a guide in photographing the underwater backgrounds, Rosenberg used an animatic of the sequence created by Dennis Muren. In some instances, the camera moves on the animatic were recorded and the data downloaded directly into the motion control camera – the idea being that the animatic moves could be translated and replicated exactly on stage. “The problem was that the moves didn’t translate exactly,” noted Rosenberg. “They could have, if we’d known from the beginning that we were going to do this; but since we hadn’t foreseen it, the CG camera wasn’t set up in a way that the motion control camera could be aligned with it. A CG camera can be anywhere; but a motion control camera has physical limitations. We were able to take some of the animatic moves directly and apply them to the motion control camera, however. There were times when we essentially lifted the move from the animatic, plugged it into our camera, and were more or less able to do the exact move on stage. It worked for about thirty percent of our shots.”

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The four-month underwater shoot was a rugged experience for the stage crew – not only because of the hardship of working in smoke, but also because of Lucas’ ‘get it right the first time’ mandate, born of his determination to make the movie as efficiently and cost-effectively as possible. “There was almost never a take two,” recalled Rosenberg. “That was the challenge – whatever we did the first time was what was going to be in the picture. But even with the pressure of working fast, the work turned out to be stunning.”

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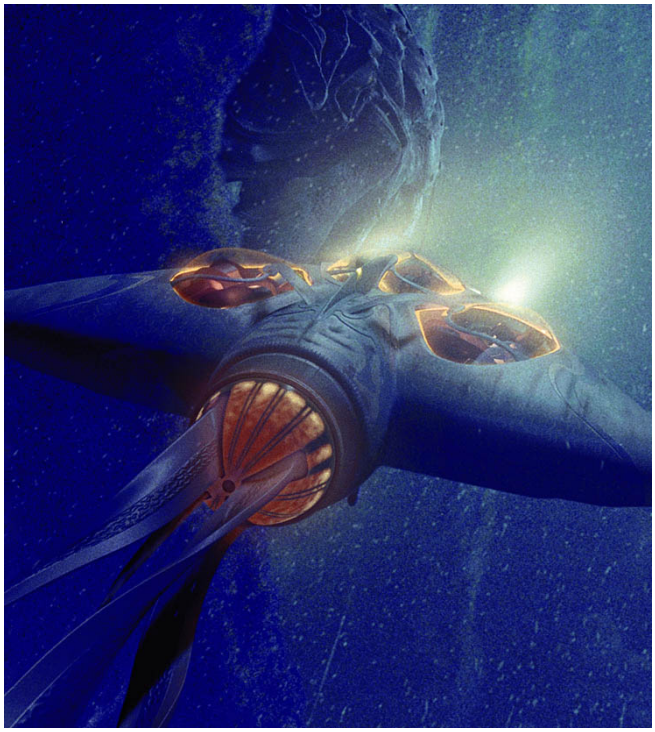
The dry-for-wet miniature elements were enhanced considerably by digital tweaking. “We added lighting,” stated sequence supervisor Kevin Barnhill, “a sort of God-ray underwater look, and a sense of depth. We also added particulate matter, using Maya software, which has lighting effects and dynamics simulations all in one package.” Bubbles were added, as well, drawn from a library of existing elements.

Jar Jar, Obi-Wan and Qui-Gon arrive in Otoh Gunga, a digital environment designed by Doug Chiang and constructed by the hard-surface modeling team. “Otoh Gunga was supposed to look like a cluster of glowing spheres supported by very ornate ribs,” explained modeling lead Russell Paul. “Like everything Gungan, the ribs were of an art nouveau style – very complex metalwork forming elegant, organic shapes. There were many different looks and types of spheres, and different rib designs, all connected through a series of tunnels that spread out to this massive city.”

Jean-Claude Langer and Ron Woodall devised the viewpaint scheme for the city, which would be viewed in beautiful wide shots. “Doug Chiang did a color painting that gave us the overall look,” remarked Woodall. “We also worked from black-and-white line art showing the outlines they wanted for the bubble silhouettes – the larger bubbles had a different structure than the smaller ones, and this created a distinct ‘skyline’ that we had to replicate.” Unique to the approach for realizing the vast underwater city was the manner in which paint drove the look. “Normally we paint a color map, a bump map and a spec map, with the lighting being addressed by a TD. But in this case, the lighting was painted into the city using texture maps. With a practical miniature, modelmakers will put a lot of little pinholes in a backlit model,

creating scale through the suggestion that these holes are windows. But if we tried to duplicate this technique in the computer, we'd have to put in hundreds of CG lights – and with each one the computation time would get higher and higher. By using an ambient setting for the texture maps and painting the lights on the city structures, we could achieve a more complex look very cheaply."

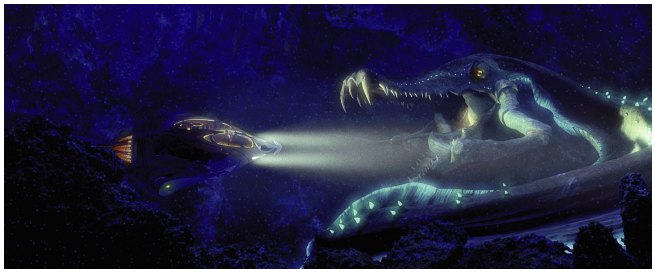
To enter the city, the characters move through a bubble-like membrane that protects the Gungan interiors from the watery environment. In a couple of shots, characters would be seen entering the bubble, stretching it as they moved through, with the membrane closing behind them. "We thought that would be an easy wipe element that we could do in Saber," observed Kevin Barnhill, "but after George saw it in dailies, he decided it wasn't going to hold up. He wanted something more elegant. We used Maya again, because of its physical dynamic properties that allowed us to stretch and break the membrane, then have it heal itself after the character broke through. We could put reflection maps on it and really see the movement and control the amount and frequency of the bounce-back. We were able to give it a sense of pliability, but enough stiffness that you didn't feel like everybody inside these spheres was in danger or unprotected. We had to give it a sense of being a magic technology the Gungans have come up with."



Rebuffed by Boss Nass, Qui-Gon, Obi-Wan and Jar Jar leave Otoh Gunga by means of a submarine. A full-size cockpit mockup had been constructed and used during principal photography for shots of the trio on board the sub, but underwater exteriors of the vessel were created digitally. A CG submarine was composited with dry- for-wet model photography – scaled rocks, tunnels and cliffs shot motion control on a smoke-filled stage.

Inside a city boardroom, Qui-Gon appeals to Gungan leader Boss Nass for help in saving the people of Naboo from the invasion. The nearly fifty boardroom shots would employ a combination of bluescreened actors, a miniature boardroom interior and a digital background. “A quite elaborate boardroom model was built and photographed for most of the interior scenes,” said Jeff Olson, “and from that they established the look and lighting of the surrounding city, which was all done on computer.” The boardroom miniature was also shot within a prac-tical dome, but these images were utilized only as reference. “Dennis wanted something that would show him what the bubble dome over the boardroom would look like from the inside. The first step was to create the dome’s shell practically, then photograph it from within to get a sense of where the various reflections might be. That reference helped the CG team develop realistic looks for being inside a bubble, as well as looking at it from the outside. We also built closeup models for the ribs that surround and contain the bubbles.”

In the course of the aquatic journey, the craft and its occupants encounter three monstrous sea creatures – all computer generated – including the fifty-foot-long opee sea killer whose design was based loosely on that of a crab.



The colo claw fish, found deep inside a cave, glowed with bioluminescence – an effect incorporated into a texture map applied to the model.xs

An entirely digital background would be seen through the thin, semitransparent membrane of the boardroom bubble set. “We wanted to have city spheres and fish and things like that floating in the background,” said sequence supervisor Christopher Townsend, “and all of those things were actually rendered. For the things that were close up, we wanted to see the parallax shift as the camera moved. The spheres were very simple, with complex textures applied. In addition, we rendered out a dozen or so groups of fish, which we then scaled and positioned as needed throughout the shots to give the scene an underwater feel. That was helped by diffusing the light and making the background more hazy the farther back it went.”

Taking an isolationist stand, Boss Nass refuses to help defend the people of Naboo against the invaders. Nass, actually a modification of the Jar Jar computer model, was resculpted by Steve Aplin to make the character appear heavier, with prominent jowls and a shorter muzzle. “Rather than working from a maquette for reference,” explained Aplin, “I was able to interpret a lot from the conceptual art and continue working from there with Doug Chiang, who gave direction as Boss Nass came together. It was great having that sort of creative input. I took the Jar Jar model into Isculpt, which enabled me to push, pull and stretch him until I got this much larger, toad-like creature that eventually became Boss Nass.”

In some respects, the Gungan leader's animation would be similar to Jar Jar's – yet Lucas instructed the animation team to make the dignified character far less loose-limbed and chaotic in his movements. "Boss Nass is a big, heavyset guy," said Rob Coleman, "and a great character. In fact, when I first read the script, Boss Nass appealed to me so much, I knew I wanted to put our hottest animators on him. He's in less than forty shots in the movie; yet he's such a wonderful character, it seems as if his is a major role." Hal Hickel, who served as Boss Nass lead animator, sought inspiration from past film performances. "We looked at actors with a similar physicality and similar mannerisms to what we wanted for Boss Nass," noted Hickel. "We took elements from several different performances. There was no chance to develop a whole character beforehand because the lead-in time was short. We had to stay loose about it." Lip-sync was particularly successful with Boss Nass, since he had a flatter, more human-looking face and mouth than Jar Jar.

Brian Blessed, who would provide the voice of Boss Nass, was on the main unit set – as Ahmed Best had been – to provide the animators with performance reference. "Brian Blessed is a big, bombastic, booming actor," said Coleman, "and he brought all kinds of lovely bits to the performance. They shot him head-and-shoulders as he delivered his lines – much like we did with Sean Connery during Dragonheart. His face and jowls were very loose as he spoke, and we were able to bring a lot of that kind of performance detail through in the CG character."

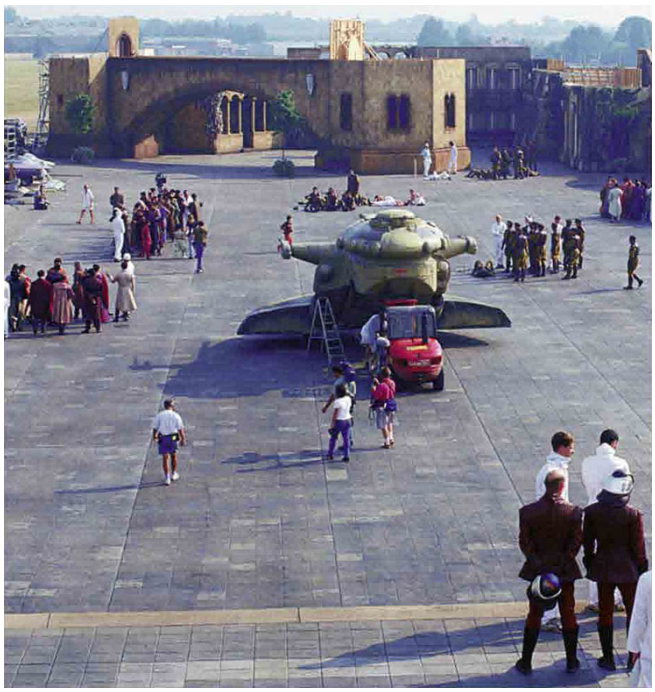
All of the major, speaking CG characters would benefit from on-set reference of the sort provided by Blessed and Best. "We talked to George early on about the importance of reference," Coleman remarked. "If we were going to make these computer generated characters as believable as his actors, we needed as much reference as possible. For this movie, we were deep in the realm of real acting. There is a certain limited range of expression a dinosaur can have; but these were real characters, real people. And we were up against some incredibly talented live actors. I wanted my people to have as much help getting there as possible."

Cloth simulation was a major issue for Boss Nass, since the character wears a large, heavy cloak in all of his appearances. John Anderson and Christopher Townsend, along with technical directors Ian Christie and Frederick Schmidt, addressed the problem. "The animation was the critical feature of the cloth simulation," stated Townsend. "The animators would animate Boss Nass, and then this cloth would be applied to the model. At that point, the simulation would say, 'Okay, if he lifts his arm, then his sleeve is going to fall down a little bit and pull over here.' It would create wrinkles when he sat down. All of that was completely driven by what the animators had done with the character, movement-wise. We hadn't devised a way, at that point, for the animators to actually see the cloak as they were animating the character; so they had to guess. For example, if Boss Nass was going to put his hand on his lap, they had to place it a couple of inches above his thigh to account for the thickness of the cloth that would be there when his cloak was added. It was very difficult for the animators – but they did a wonderful job of working around the problem."

The Jedi and their Gungan sidekick proceed wth haste to Theed, the capital city of Naboo, only to find it already occupied by Federation forces. Wide shots of the elegant city were created entirely through visual effects – via elaborate miniature sets and digital matte paintings – under the supervision of Scott Squires.

In the city’s central plaza, the Jedi come to the rescue of young Queen Amidala (Natalie Portman) who, with her royal entourage, has been taken into custody by Federation battle droids.

One characteristic that would distinguish Boss Nass from his fellow Gungans was a magical lighting on the character – an effect Lucas and the Muren team had envisioned very early in Boss Nass' development. "We found that he looked really good with this dramatic backlighting on him," Townsend observed, "so it was decided that we would always try to light Boss Nass with this in mind. That proved difficult in shots with Liam Neeson and Ewan McGregor right next to him – obviously, we had to tone down the dramatic lighting in those cases and take our lighting cues from the real actors. But we always tried to maintain some of this dramatic sense with the character. Hal Hickel, Sue Campbell and Tim Harrington – the three animators who were most responsible for Boss Nass – did a great job of bringing this character to life and making him look like a majestic being with a real sense of pride and stature."



Live-action for scenes in the plaza was shot on a minimal backlot set – at Leavesden Studios in England – which, later in postproduction, was extended both vertically and laterally via miniature or digital set extensions.

Also introduced in the Otoh Gunga scene is Captain Tarpals, the Gungan military commander. Sunny Wei, working without benefit of a scanned maquette, modeled the Tarpals character from scratch. For reference, Rob Coleman had Tarpals' vocal performance on tape. "For the most part," acknowledged Coleman, "George just talked me through the character of Captain Tarpals. He is a quiet, stiff, military guy – the complete opposite of Jar Jar. Where Jar Jar had to move as if he had no bones, this guy was nothing but bones."

With Boss Nass' refusal of assistance, Qui-Gon, Obi-Wan and Jar Jar leave Otoh Gunga in a submarine and encounter three monstrous sea creatures in their underwater journey. A practical, partial submarine mockup had been used on the set for shots of the actors sitting in the craft, but wider exterior views featured a computer generated sub. The CG sub, like all things Gungan, was an organic-looking form with an art nouveau influence that translated into curved lines and intricate detailing – all of which presented modeling challenges. "The submarine looked something like a manta ray," stated Russell Paul, whose hard-surface modeling group built the craft. "It had a triangular head and a long tail that propelled it along. It was very alien looking. Even though it has a propeller, it seems organic, with ornate filigree blending into mechanical features."

Although much of the sub detail was modeled, Jean-Claude Langer added to it during the viewpaint stage. "Despite the fact that the submarine is underwater in a dark and muddy environment," said Langer, "all the details had to be there. The camera got in very close, and sometimes the sub came into the light. At those times, every part of it would be revealed."

Surrounding the submarine was an energy shield – reminiscent of the protective membrane in the bubbles of Otoh Gunga – generated from a device atop the vessel. “The most obvious, straightforward way to do that,” related Jon Alexander, “was to render a 3D object and put all the reflections and the energy effect onto that. But that would have required a 3D matchmove. So we cheated it with a 2D approach, faking the reflections on it, which took a lot less time. It wasn’t precisely correct, but it was cheaper in terms of machine time to do it that way.”

The first sea monster encountered by the sub is the opee sea killer, a crab-like creature, fifty feet long. “The opee attacks the submarine,” recalled Dennis Muren, “then a much bigger creature – the several-hundred-foot-long sando – comes along and attacks the opee.” The sando aqua monster was conceived as a serpentine beast with a whale-like head. Later in the sequence, the seafarers go into a tunnel and encounter the colo claw fish, a hundred-foot-long cross between a barracuda and an alligator. “When they’re in this tunnel they lose power, so they don’t know where the heck they are. Finally, when the power comes back on, their headlights light up the eyes of this creature – and that’s a big reveal. I treated the colo as if it were a sleeping cat, which wakes up, uncurls itself, chases after the sub, and then swims right into the mouth of the sando.”

In the digital modeling department, Howie Weed fashioned the colo from scratch, Jim Doherty built the opee and Wayne Kennedy built the sando. Later, however, the sando underwent redesign and remodeling to better sell its enormous size. “He was designed with a dragon-like face,” explained Geoff Campbell, “but his features were quite large, which ruined the sense of scale. Generally speaking, the larger the animal, the smaller its facial features. Richard Miller and his crew created another maquette, which was scanned; and a new computer model was then built by Alyson Markell.”

The scale of the creatures was also a central issue within Rob Coleman’s character animation group. The enormous sando, in particular, had to be animated to move very slowly, as if it were displacing tons of water with each swim stroke. The suggestion of mass was further aided by the paint schemes implemented by the viewpaint team. In the end, scale issues demanded that the original brightly colored paint schemes for the creatures – devised by Doug Chiang and his department – be revamped as the underwater sequence went into production. “The bright coloring really worked against the scale,” observed viewpaint supervisor Jean Bolte. “In nature, the bigger an animal is, the more muted its coloring. So we toned down the coloring, especially on the sando.”

The viewpaint team would also play a major role in creating the colo claw fish’s luminescent qualities. “Originally,” stated effects art director David Nakabayashi, “everything underwater was going to have this bioluminescent quality – all of the fish, and even the terrain. But that idea was tossed because of time considerations. It was felt that the research and development for that would have taken too long. But the idea stuck for the colo fish. We developed the look using concept art in Photoshop. We shot the maquette, which was eighteen inches long, and we scanned it and put it into the computer environment. Then we painted a concept piece of what its texture ought to look like. It was viewpainted by Jean Bolte and used a shader, which meant we were telling the paint to have a certain luminescent quality. Then, in the comp, the TD added

things like blur and a screen effect, which made it look like it was glowing and lighting up the liquid environment. There was also a very subtle pulse to the glow, which required animation."

The heroes survive the creature encounters and make their way to Naboo's capital city of Theed, already overrun with Federation battle droids, tanks and ranking Neimoidians arriving in the city's plaza via troop transports. Theed was imagined as a paradise, its dreamy vistas basking in perpetual magic-hour lighting. The concept – developed by Lucas and Doug Chiang – was of an elegant, ancient city, much like Venice, surrounded by tropical jungle and crisscrossed with canals. Everything literally flowed toward the royal palace, which was perched dramatically on a cliff streaming with waterfalls.

Views of Theed were realized both practically and digitally. "Whenever we approached a shot," stated Scott Squires, whose team would create the cityscapes, "we'd ask ourselves which was the best technique, computer graphics or minature. There was a palace hallway, for example, which had a lot of straight lines and lens distortion issues – so we felt we'd be more in control utilizing computer graphics for that. But we went with miniatures for other shots where there was a self-contained environment or the buildings were very complex."

For the model shop, the construction of Theed was one of its most ambitious projects. The work concentrated on an area of the city that included the queen's palace and a huge archway opening onto a tile-paved plaza. The architecture, encompassing public areas and royal grounds, was designed as a mixture of Moroccan, Mediterranean, Indian and Egyptian influences. "The plaza is the cultural area of the city," commented Charlie Bailey, an ILM model shop member since The Empire Strikes Back. "Theed is supposed to be an old, but well-kept city that at some time was remodeled, so there are old buildings outfitted with modern doors and card-pass locks."

Bailey and his crew of forty-two had only about two months to construct Naboo's capital city structures – miniatures that would ultimately figure in eighty shots, spanning six to eight sequences. The strategy was to produce modular, individual buildings that could be reconfigured as desired to create many different cityscape views on an outdoor motion control stage built specifically for the production. The final sixty-eight structures – executed at thirtieth scale with more than six hundred separate pieces – were finished on three sides, with windows, doors and other detailing different on each, providing multiple building elements within a single model.

The intricacy of the architecture was evident in the domed archway leading into the elegant promenade, which alone took almost as much time to build as the entire district surrounding it. "The dome was a four-foot-diameter hemisphere," Bailey described, "a blown-acrylic bubble we farmed out, then trimmed to shape." Lorne Peterson – another modelmaker from the Star Wars days – sculpted a ceiling pattern for the dome, then vacuformed plastic over it for the inside arch.

The detailed models – ranging from five-foot buildings to eight-foot spires – were generally built with ultralight MDF, a masonite type of fiberboard that was hand-cut with table saws. For elaborate detailing, cutting of windows and grille work, the department utilized a computer numerical control laser cutter. "That has revolutionized things," Bailey stated, "especially for

making correct architectural models that would take months to do by hand. We'd draw a design in CAD and plug that into the laser, which used the diagram to cut the material."

The modeling included cornice work made from lumberyard and Italian wood trim, vacuformed elements such as doorways set into buildings, copper roofs and hand-sculpted statues such as the heroic winged figures gracing the palace steps. A team of nine scenic artists headed by Steve Walton painted in miniature, adding everything from marble simulations to aging effects on metal structures. Intricate detailing included banners, lampposts and a 'hanging gardens of Babylon' effect of foliage dressing walls. "The trees were different scales of fiber-wound metal trunks and some manzanita bushes we cut," Bailey explained. "We also fabricated foliage with shredded foam and dyes. We brought in truckloads of dried flowers we handpicked and glued on. When everything on the outdoor set was dressed out, the occasional butterfly would try to feed on the flowers, and birds would land on the trees."

Each morning on set began with the ritual huddling of Doug Chiang, Scott Squires and Marty Rosenberg as they worked out final model configurations for the day's shoot. "Designs would change," observed Bailey, whose team dressed the models for camera, "and every day the models would be shuffled around to see what looked best. It was like an enormous chess game." The outdoor shooting setup was a forty-by-forty-foot platform that rotated to enable the camera crew to capture specific sun angles throughout the day. A fourteen-foot crane arm was set on a pedestal base on motion control tracks to get a bird's-eye view of the miniature metropolis. To scale the artificial flowers and trees as they rustled in the breeze, the Vistavision camera generally ran at sixty frames per second.

The miniatures were always backed with bluescreen to allow flexibility in crafting the final image – sometimes completed with a matte-painted sky or distant painted views of outlying districts. Portions of the model buildings would also match the Leavesden Studios backlot sets, which comprised the base of the palace and its adjacent structures, erected to a two-story height. Key to shooting the models was matching live-action lighting that had been captured on those studio sets. Rosenberg's ritual was to consult a computer program that could tell him where the sun would be at any given hour on any given day at thousands of locations around the world. "It would tell me I'd have to shoot at 1:30 PM to get a specific light angle," said Rosenberg, "then, to position the set for the chosen lighting, we'd rotate the platform into place."

Digital matte paintings by Brian Flora provided establishing views of the palace. As a start, Flora and matte painter Caroleen Green produced quickie mood paintings, casting a scene in a particular light, conjuring up dreamy cloud formations or simply raising creative possibilities for consideration. One daytime shot was a dramatic flyover of the palace and its cliffs, a view to the outlying city and surrounding jungle. "When doing this shot," observed Flora, "I kept thinking of those movies where you go to Washington D.C. and there's this rotating helicopter shot above the Capitol or the White House. I would operate the virtual camera in that manner, then show the move to Scott Squires, Doug Chiang and finally George for approval."

Louis Katz modeled the palace in its digital form, with Flora then mapping still photos of marble and other textures onto the geometry. Katz also modeled and textured roughly twenty low-resolution buildings based upon scanned reference photos of Theed miniatures, taken in mid-afternoon to catch dramatic shadows. The buildings were then incorporated into Flora's 3D matte paintings. The shots were embellished with flocks of CG birds and image-processed waterfall elements done as a classic stage gag, with twelve-foot streams of salt poured down black shapes and shot high-speed by Marty Rosenberg's crew.

On an outdoor shooting stage, Doug Chiang and modelmaker Phil Brotherton inspect the Theed miniature which, fully configured, was comprised of sixty- eight separate structures. The thirtieth-scale city set was shot on a motion control stage built specifically for the production. The stage – a revolving platform – enabled the model photography crew to turn the set at will, thus capturing appropriate sun angles regardless of the time of day.

Flora utilized a combination of elements for the surrounding terrain. "For the cliff face I built a miniature out of aluminum foil, with lichen added for foliage texture. I photographed that miniature in the late afternoon sun to match the color scheme, and used it as a basis for my Photoshop painting. I also incorporated photographic references of Hawaii and Arizona to flesh out details in the cliffs and surrounding jungle. The painting was then texture-map-projected onto simple geometry, which allowed the move through the environment."

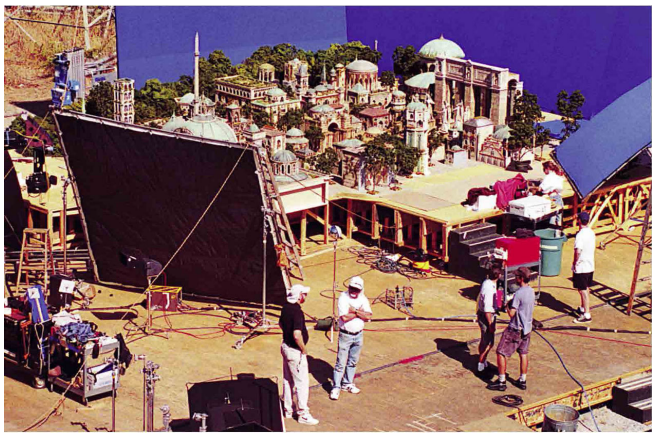
A detail of the palace entrance. Theed miniatures were built in a modular fashion so that buildings could be rearranged and dressed to camera on a shot-by-shot basis.

Once in the city, Qui-Gon, Obi-Wan and Jar Jar make their way to the palace of Naboo's Queen Amidala (Natalie Portman), who has been detained by a small regiment of battle droids. From a walkway high above the scene, the Jedi knight and his apprentice leap down into the plaza, taking the droids by surprise and dispatching them in short order, rescuing the young monarch. Some plaza exteriors had been built and filmed on the Leavesden backlot during principal photography; but the full scope of the setting was not realized until sequence supervisor Sean Schur's team filled in the existing live-action with both digital and miniature set extensions.

The Squires unit produced many such set extensions for the film. The fusing of practical sets and virtual extensions was full of mind-boggling complexities, such as light-matching problems between live sets, CG sets and miniatures. "The biggest challenge on a day-to-day basis," Schur recalled, "was getting coherent images from all these disparate elements. In CG we could light something any way we wanted to; but since the live-action and miniatures were often shot at

different times of day, we would have to fine-tune all three – the live-action, the CG and the miniature shots – to make everything look as if it belonged." In some cases, CG set extensions had to be reconfigured to allow for a new camera move suggested by Lucas after the fact. "Sometimes we'd create a CG building for a far background, so we painted it at low-resolution; then the shot would change and suddenly this background building was in closeup, so we'd have to repaint and provide more detail. We were constantly working and reworking these set extension shots."

Another set extension extravaganza is revealed as the action moves into Theed Palace, where the queen and her guards are chased by battle droids down long hallways lined with marble columns. A soundstage set had been built in England – fifteen feet tall, thirty feet wide and one hundred feet long. That set was extended in the computer to fifty feet tall and nearly eight hundred feet long. To avoid the look of a replicated model, each turn of the corner had a different embellishment, with digital matte painters adding side hallways, ballrooms and other singular details. Some of the extensions were created with paint by duplicating a section of column or hallway to achieve the desired dimensions. In addition, technical director Andy Wang wrote a script for expanding a single hallway – built by Jack Haye – into a maze of hallways. "We built many alternates of the palace hallways by reusing the same pieces of geometry in different compositions," noted digital modeler Andrew Cawrse. "Variations in paintwork by Scott Bonnenfant were also applied to further the illusion of new architecture."



Large bluescreen backings were erected on the outdoor stage so that digital matte paintings and 3D buildings could be composited into the extracted areas to extend the miniature for wide shots.

Digital matte painter Brian Flora and technical director Lou Katz at work on an all-digital representation of Theed that would reveal the city from a distance. Photos of the model buildings were scanned to provide textures that could be applied to 3D shapes within the matte painting. Embellishing the scene were computer generated birds and waterfall elements achieved, rather primitively, by pouring salt against black.

In many scenes with actors running down hallways, the performers were extracted from the live set and placed into wholly virtual environments. "We tried to keep as much live-action as possible and extend things in CG," noted Schur, "but there were cases where the set floor wouldn't match up with our floor, so we'd completely rotoscope out the actors and make the entire environment CG. When we did that, we also had to separately rotoscope out and put back their shadows and reflections."

Having rescued Amidala, the Jedi knights lead her and her entourage – pilot, navigator and handmaidens – to the hangar where the queen's ship is docked. The plan is to escape Naboo and proceed at once to the Republic capital of Coruscant, where the queen will plead her planet's case before the galactic senate. The hangar sequence – also handled by Squires' team – would comprise both a partial set built at Leavesden and dig-ital elements that would extend the hangar to eighty feet tall and hundreds of feet in length. The 3D hangar, modeled by Andrew Cawrse, was filled out with other computer models such as the massive queen's ship, forty-two Naboo starfighter craft, fourteen docking bays, a landing track, landing lights along the floor and various hangar doors.

The hangar's scale and complexity underscored the fact that The Phantom Menace was rewriting the rules for visual effects techniques. "In a single shot," said Barry Armour, "there could be CG and bluescreen elements, live-action plates with practical sets extended in CG, digital actors and matte paintings. In the hangar, for instance, George needed a reverse shot but he didn't have an appropriate set; so he had us flop the image left-to-right and cobble a shot together by inserting a rear wall section and footage from other scenes."

Ultimately, the practical hangar set filmed at Leavesden represented less than twenty percent of the final structure, the remainder of which was completed by Cawrse using production blueprints, photographic set references and input from Doug Chiang. Unlike set extensions of the past, which could only be incorporated into locked-off shots, these digital sets and environments would be used in conjunction with moving-camera live-action. The freedom of movement afforded by the virtual camera meant that any digital model could potentially be seen in closeup. As a result, each one had to be built and detailed to stand up to scrutiny. "As with any CG set or environment," said Cawrse, "the balancing act is how much geometry is needed to create a successful illusion while still being efficient in construction and rendering time. We modeled the hangar with a lot of detail at floor level, and reduced the level of resolution as we went up to the eighty-foot ceiling. Due to its repetitive nature, the model was broken into six highly detailed units that were used in different combinations throughout. The positive aspect of set extension was that we had a live-action set to continually match for modeling, painting and rendering. The negative aspect was that we had to be incredibly accurate, since the wide-angle filming that was used would reveal the slightest difference in perspective, paint, detailing and lighting."

Through viewpaint, textures were mapped directly onto the 3D models and surfaces. Hangar textures ranged from stucco walls and glossy floor surfaces to metal fittings securing the starfighters. Painters also utilized displacement maps to create deep crevices, recesses and other textural effects. Viewpainter Donna Beard worked with a team of painters – including principals David Saccheri, Kerry Miller and Joe DiCesare – and with sequence supervisor Dave Meny to devise a formula for matching the hangar set. "A lot of hangar textures came from photographs of the live-action set," related Beard, "which were then carefully manipulated and painted onto the 3D surfaces. A big issue was how best to deal with scale. Our maps were very large because paint had to hold up at a distance and close up."

The challenge of scale was even more of an issue as the textured models were passed to sequence supervisors and technical directors for rendering, and then to the compositing group. The new Star Wars was not the streamlined effects show of old, with location data easily plugged into the matchmove on a single CG element. Complications arose with first-unit plates that broke all the once-inviolate rules of composite photography. In England, Lucas had worked with a constantly moving camera – often without even a bluescreen in place. Another challenge was that main-unit photography throughout used wide-angle anamorphic lenses, resulting in a slight 'barrel distortion' effect towards the edge of the frame. Effects artists had to match their elements to those distorted plates.

Lens distortion was particularly problematic in the hangar, where the vertical lines of soundstage walls and columns had to line up perfectly with virtual extensions. "Whenever you're blending live set and extensions, the linchpin is the matchmove," remarked Barry Armour. "An image is generally determined by the geometry plus the camera position related to the geometry, and the focal length of the lens. But with the barrel distortion of wide-angle anamorphics, when you try matching a move you end up with an undefined focal length on the camera matchmove lens." Another effect of the wide-angle plates was that when the matchmoving department began working in low-resolution, as was customary, they quickly discovered that they needed to be at full film resolution in order to get a handle on the lens distortion issue. To address the problem, Squires' unit employed a process of removing the distortion introduced in the original lens by applying the inverse, through image processing. "They'd flatten the plate," explained Squires, "then do the matchmove in 3D space. Afterwards, we'd start putting in any CG characters, all of which had to go through an inverse distortion. This meant that the CG characters or sets in the final composite had to be given the same lens distortion as the original element – and if those parameters were not quite right, we'd have to either recomposite with a different distortion or revisit and refine some of the matchmove positions."

Film grain – adding it, matching it, taking it away – became an important issue, not only for the Theed hangar sequence, but for other scenes throughout the movie, as well. "Grain was a concern because George was doing a lot of cropping, taking bits and pieces of images and putting them together to make a new image," explained Armour. "Often he'd reduce an image, which meant reducing grain size and changing the grain characteristics. With a reduced, cropped image, we had to decide whether to match that or get rid of the grain and add new grain to match the surrounding cuts."

In the compositing stage, the technical directors worked on rough composites, while a separate compositing unit took images to a final. It was in the compositing stage that color timing, consistency of grain, blending edges and other issues were addressed. Fortunately, given the size of the project, an arsenal of new interactive compositing tools was available. The major in-house compositing breakthrough was Comptime, developed by Jeffrey Yost on Twister and used in earnest on The Phantom Menace. "Comptime made life easier for the TDs and compositors," said compositing supervisor Greg Maloney. "If we needed to do a particular function, such as a dissolve, instead of writing lines of code, all we had to do was go to a pull-down menu for the dissolve function."

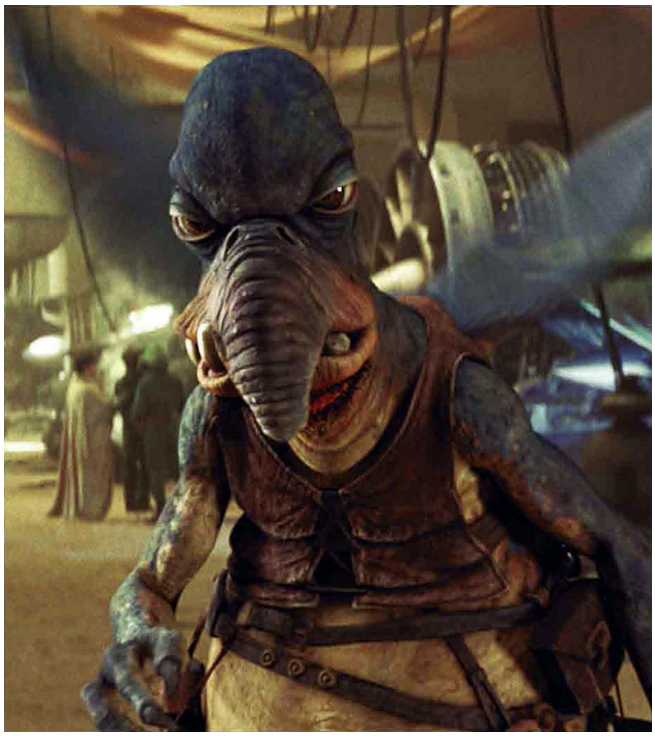
Under fire from Federation forces, Amidala and her rescuers manage to escape the planet in the queen's ship. The sleek vessel – adorned with a reflective chrome finish – abounded with compound curves, a design aspect reflecting the predominant décor of Naboo. To facilitate dealing with those smooth, arching lines in the digital realm, a thirty-inch model, built by the model shop, was cut into one-inch sections and scanned into Alias by Russell Paul, who used the data as a basis for his dig-ital model. While initial cuts of the vessel still within the Theed hangar were executed by Squires' team and went through the established animation pipeline, subsequent scenes involving the ship in flight were executed by John Knoll's rebel unit.

ACT 2

Damaged by Federation weapons fire during its flight from Naboo, the queen's ship diverts to Tatooine for repairs. The desert planet of Tatooine had been introduced as Luke Skywalker's home in Star Wars; but while that movie's Tatooine scenes had been set in the city of Mos Eisley, the setting for the second act of The Phantom Menace would be Mos Espa. Full-size sets representing the streets of Mos Espa were erected in the Tunisian desert for live-action shooting. During the landing sequence, however, the city of Mos Espa is seen in the distance – a view cut-and-pasted together from still photographs shot by John Knoll while on location.

Qui-Gon, Obi-Wan and Jar Jar escape with Amidala and her entourage aboard the queen's ship – which is damaged in the flight by Federation weapons fire. The group sets course for the outlying planet of Tatooine to make repairs. Once there, Qui-Gon barters for essential parts with local junk dealer Watto, a flying Tryderian of questionable ethics.

Those photographs would also serve as reference for digital matte paintings of the city, created by Rick Rische. For shots of the queen's ship on planet surfaces – not only on Tatooine, but also on an aerial landing pad at Coruscant and in a Naboo jungle – a physical miniature was fashioned. "I decided to have a large model of the queen's ship built for the scenes where it was parked," explained John Knoll, "primarily to reduce the 3D workload. Constructing this model meant that about two dozen shots could be shifted from 3D to 2D – and that helped with resource allocation. Furthermore, I thought taking the chrome model out into the parking lot, setting it up on a sandy table, and shooting it in the full glare of the noon sun would result in more realistic images than even weeks of computer rendering could offer."



Knoll determined that the already built queen's ship scanning model was too small for such purposes, lacking sufficient detail to withstand scrutiny at length, but that a ten-foot miniature would suffice. Russell Paul's digital model was converted into a data file from which the model shop could mill out an accurate shape, cut from foam.

Watto's junk shop, Qui-Gon and C-3PO have to share a cramped quarters with Watto's bizarre assortment of junk. Watto was a digital character, built by Steve Aplin, viewpainted by Jean Bolte, enveloped by Cory Rosen and Tim McLaughlin, and chained by James Tooley. Tooley also wrote a special program, called Glue, that enabled tools to hang and swing from a utility belt that Watto wears.

In Mos Espa, Qui-Gon goes to a local junk dealer, Watto, to find the parts needed to repair the ship. A three-foot-long, flying Tryderian with a short trunk, walrus teeth, big bulging eyes, a bald head, a three-day growth and webbed feet with claws, Watto was a digital character, built by Steve Aplin, viewpainted by Jean Bolte, enveloped by Cory Rosen and Tim McLaughlin, and chained by James Tooley. Tooley also wrote a special program, called Glue, that enabled tools to hang and swing from a utility belt that Watto wears.

From an animation perspective, the challenge of Watto was that the character would be flying throughout his scenes. Both to develop Watto's personality and to resolve technical issues, an animation test was created in Softimage very early in ILM's production schedule. "It was evident from that first test that we would have to explore motion blur techniques to create Watto's fast-beating wings," explained lead Watto animator Linda Bel. "We created a wing-beat cycle and let the shape of the motion blur help define the speed of the wing flap. Bruce Dahl and Tom Hutchinson worked on this, coming up with five sets of wings on each side, using the same animation cycle, but offsetting it in Softimage and applying motion blur."

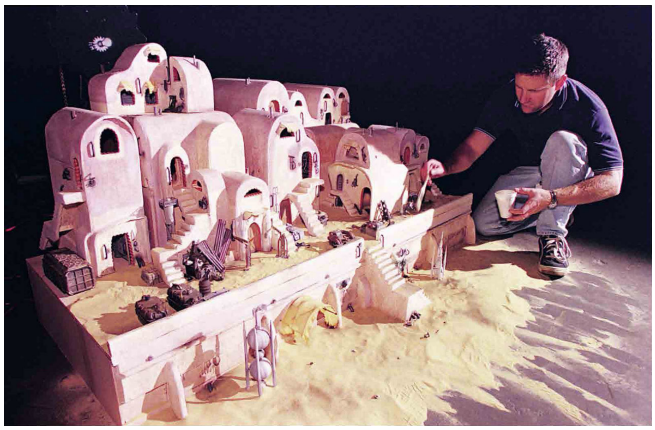
Selling the fact that the overweight, pot-bellied Watto could remain airborne with only the flapping of his disproportionately tiny wings was the animation team's most difficult task. "Those two short little wings clearly could not lift him," observed Rob Coleman. "So the physics were all wrong – which made the animation more difficult. To come up with a flying cycle, we imagined a flying water balloon: the wings suspend his upper body, with this bulbous underbelly swinging underneath him. There had to be a willing suspension of disbelief – as there was all through this movie. You just had to say, 'Okay, these wings can lift that body – no problem.'" Changing the wing cycle as Watto hovered in place, lifted or let himself drop helped the reality of the character's flying. "We animated the wings to beat faster or slower, depending on what he was doing. And because he is overweight, there's a bit of labor and bobbing in his flight, as if he's really having to work hard at staying up."

Other elements of the Watto animation referenced the vocal and on-set performance of actor Andy Secombe. "The way Andy played him, there was something endearing about Watto, even though he's this shifty character," stated Coleman. "Andy gave him a great voice; and right away, just from listening to that, we had a bunch of material to work with. His on-set stuff wasn't as useful, because he was walking and Watto would be flying; but he created little nuances with his hands, his face, his head and his eyes, all of which I had the animators recreate."

Lip-sync was especially difficult to achieve in the animation of Watto, due to the Tryderian's physical characteristics. "Watto had twin tusks, top and bottom, and a snout," explained

Coleman, “yet he had to speak and be understood. Once we got into animating him, we found we just could not make the recorded voice sound as if it was coming out of that mouth. So we had to compromise the initial design by chipping his tusks away on one side and having him speak out of that side of his mouth. It was an example of a creature design that looked beautiful on paper, but didn’t work well in three dimensions.” Working from drawings by Doug Chiang and concept artist Iain McCaig – plus photographs Coleman took of himself to illustrate how Watto might squint and talk out of the side of his mouth – Steve Aplin assembled a library of facial shapes for Watto.

The method used for lighting the character was a departure for ILM – one that would ultimately impact a majority of the CG characters on the show. “In the past,” said sequence supervisor Howard Gersh, “we’d set up lights in virtual space, then track a CG subject. This time, our lights tracked with the CG subject. By setting up this special lighting rig, we could emulate the parallel-light-ray look of the sun’s rays.” This linked, light-to-subject approach – the lighting ‘null’ position – required considerable finessing to keep the sun source anchored whenever a character turned or spun around, but paid off in the way it expedited production. “By varying the exposure levels on the CG lights using this lighting null, environmental changes could be introduced. Sunlit scenes would get a ‘three’ exposure – three stops over zero, or null – while interiors got correspondingly less exposure. This methodology gave us consistency throughout a large number of shots.” The lighting null was applied to about ninety percent of the creatures in the film.

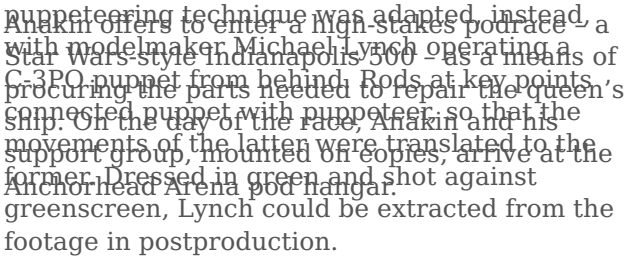


Although full-size sets had been erected in Tunisia, wide views of Anakin’s slave quarters were captured with a miniature, detailed by digital matte artist and former modelmaker Bill George.

Since C-3PO would be presented as an unfinished prototype, with inner mechanisms and wiring exposed, the man- in-a-suit approach used for the first three films was no longer feasible. A Japanese

While negotiating with Watto for ship parts, the Jedi, Jar Jar and handmaiden Padmé (Natalie Portman, in a dual role) make the acquaintance of Anakin Skywalker (Jake Lloyd), a gifted boy who has been sold into slavery to the junk dealer. When a storm erupts, Anakin invites Qui-Gon’s entourage to his slave-quarters hovel, where his mother Shmi (Pernilla August) prepares dinner for the group. The scene at Anakin’s hovel would also introduce the droid C-3PO, a pet project of the mechanically inclined Anakin. Now only a partially skinned, prototype robot, Threepio would look

considerably different than the beloved character of the first three Star Wars films.



Anakin offers to enter a high-stakes podrace – a Star Wars-style Indianapolis 500 – as a means of procuring the parts needed to repair the queen's ship. On the day of the race, Anakin and his support group, mounted on eopies, arrive at the Anchorhead Arena pod hangar.

puppeteering technique was adapted, instead, with modelmaker Michael Lynch operating a C-3PO puppet from behind. Rods at key points connected puppet with puppeteer, so that the movements of the latter were translated to the former. Dressed in green and shot against greenscreen, Lynch could be extracted from the footage in postproduction.

At ILM, chief modelmaker Michael Lynch and a small crew were tasked with devising the character, given just two months to pull their practical creation together before shooting was to begin. Whereas the original Threepio had been accomplished with performer Anthony Daniels in a robot suit, the current version – minus skin and with much of its inner workings exposed – would be constructed as a rod puppet, operated in a manner similar to bunraku, a form of Japanese puppet theater in which black-clad puppeteers work directly behind the puppets, in view of the audience. Lucas, seeking a non-digital means of creating the droid, had suggested the somewhat unorthodox approach. "George saw a puppet show on television," said Lynch, "where the puppet's feet were actually attached to the puppeteer, and they were dancing together. I think it inspired him to go in that direction for C-3PO."

Working with Lucas' idea, and guided by conceptual art from Doug Chiang's art department, Lynch and his team first built a quick-and-dirty prototype of the puppet using foamcore cutouts, with rubber hoses for joints and baling wire holding it all together. Rods connected key control points on the mockup to like points on the puppeteer, who was positioned directly behind the puppet so that as he moved, an identical movement was exacted from the puppet. "We wanted to see if the concept would work," Lynch explained, "and, if it did work, how many rod connections I was going to need to get the kind of performance that was required. We shot a little video test with bluescreen, and it looked promising. It gave us the confidence to go ahead and do the real thing."

Design of the puppet followed a mandate that certain familiar aspects of the original C-3PO be incorporated into Anakin's work-in-progress. "There were certain things George wanted to see," remarked Steve Gawley. "He wanted to see recognizable features from the original – the eyes, the stomach plate, the knees, the feet and hands. To give it that little extra something, he also wanted to see some innards working. So we built some rotating pieces inside the chest and some blinking lights; and in the head we had the brain rotating and the eyes lighting up. The idea was that this nine-year-old has found all these parts in a junkyard and constructed C-3PO from them."

The construct was assembled with an eye toward keeping its weight down to one hundred pounds, since Lynch – who would handle the puppet on set – would have to bear the full brunt of the load. "We used half-inch, laser-cut plexiglas and a variety of plastics for the skeleton," said Lynch, "with nylon for some of the ball-and-socket joints. We sculpted the head, and vacuformed over that to cut out the parts that were recognizable. It was a matter of getting the skeleton to operate correctly, then going from there in terms of how much we could stuff inside it without inhibiting its motion." To further reduce its weight, Lynch filled the puppet with yards of lightweight tubing and hoses, and drilled weight-lessening holes into everything.

On set, Lynch was positioned just inches behind the puppet, linked to it via fourteen rods that extended from various points on a specially rigged suit he wore to corresponding points on the droid's anatomy. "I wore a hardhat with three head rods – one on each temple and one on the top of my head – that connected to C-3PO's head," explained Lynch. "I had two arm rods, two hip rods, knee-to-knee rods and ankle rods. Then a harness went over my back to support his weight, so that he was cantilevered off my chest. Just by the design of him, his motion was limited and he wasn't terribly dexterous; but that actually supported the story point about this being a prototype. He's not supposed to be as sophisticated as the finished product; he's just learning to walk, so he's a bit clumsy and shaky." To facil-itate later digital removal of the puppeteer, Lynch wore either an all-black suit or ones that blended into bluescreens, greenscreens or sandy Tunisian backgrounds. "I also had a hood over my head, so you didn't see my face in the picture."

Though camouflaged, the puppeteer was still clearly in the shot and had to be extracted digitally. Ultimately, about twenty C-3PO shots required puppeteer removal – a task complicated by the fact that the shots had not been filmed motion control. "Many shots included pans and tilts," observed John Knoll, "so without motion control, we could only try to match the camera movement with a freehand move on an empty set – which at best just approximated the original plate."

"The camera operator made a valiant attempt to duplicate the original move on a blank plate pass," lead rotoscope artist Jack Mongovan added, "but sometimes as much as half of the plate would be missing. We often had to pull from several different takes to rebuild the image completely." There were other roto problems with the puppeteer work, as well. "The operator's shadow wound up on the wall often, and that could mess with C-3PO's shadow or that of another character. We would extract the puppeteer's shadow, and sometimes have to do the same for the droid, depending on the requirements for each cut."

Qui-Gon makes a wager with Watto that will result in his acquiring the parts needed for his ship and the release of Anakin from servitude if the boy wins a podrace – the Tatooine equivalent of a down-and-dirty drag race. The ten-minute-long, centerpiece podrace – a kind of science fiction homage to the chariot race in Ben-Hur – would feature a wider array of computer generated characters, particularly in its motley assortment of pod drivers, than any other sequence in the picture. Chief among them was champion podracer Sebulba, a Dug from Malastare. The whimsically designed alien walked on his hands, using his feet as hands, and had a horse-like face with a long snout and eyes on the sides of his head.

Paul Giacoppo modeled Sebulba, who was animated principally by Patrick Bonneau and Miguel Fuertes, with Kyle Clark and Ken King joining in later, and Kim Thompson contributing to some of the character's thirty shots. "In terms of movement, George wanted Sebulba to be reminiscent of an orangutan, a spider and a sloth," recalled Rob Coleman, "and that was all we had to go on. The orangutan part of it was taken from the way some primates will walk on their hands and tuck their feet underneath them – and Sebulba does some of that. There is also the creepiness to the way his legs move, like a spider's, and the slowness and strength of a sloth. Sebulba is a speaking character, but he doesn't speak English, so his lines are subtitled. That

was to make him more mysterious, more alien." Sebulba would be introduced in a marketplace scene in which he gets into a confrontation with Jar Jar – a particularly challenging animation task, since it involved much physical interaction between two digital characters. The remainder of Sebulba's appearances take place before and during the race.

Making a brief appearance at the podrace as a spectator was Jabba the Hutt. "For the young Jabba," stated Geoff Campbell, "we referenced photos of the original puppet in Return of the Jedi. Although many years younger in this show, he is still distinctly Jabba, with his prominent chins and wide mouth. Alyson Markell worked from a maquette as a starting point, but did a lot of hands-on work to create the fatty skin folds that added weight to the character."

Qui-Gon and Padmé accompany the young slave to Anchorhead Arena, where the perilous cross-country podrace will begin and end. Unenthusiastic about creating the whole stadium with computer graphics, John Knoll called upon Lorne Peterson to supervise the creation of an extensive practical miniature arena. "It's difficult to realistically render CG architectural models," said Knoll, "and this is largely due to issues of diffuse interreflectivity and the quality of shadows involved. Since all of the podrace shots were daytime exteriors, it made sense to go outside rather than try to fake it inside on stage." The arena, measuring forty feet across, was the principal element in the ninety-by-thirty-foot landscape model.

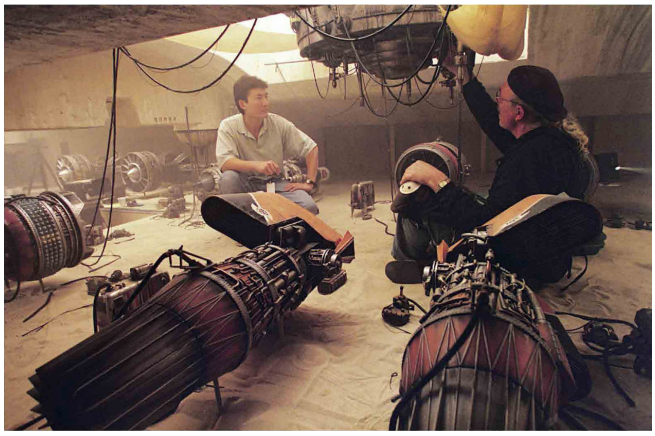
Out of ninety arena shots, seventy were static and could be photographed as stills, with several matching images scanned into the computer so that grain could be averaged out and a clean image produced. Twenty of the Anchorhead shots, however, including the sweeping helicopter-like first reveal of the arena, featured camera moves and had to be done as motion control exteriors. Knoll had gone through the animatics of the podrace before principal photography to determine the optimal position for the sun, shot by shot. But the first unit was unable to adhere to his plan, since the partial live-action arena set in Tunisia was filmed over a two-day period in lighting situations that ranged from early morning to late afternoon, with the sun shining from every possible direction. "Since you cannot have a sunlit foreground character lit from the right with the background lit from the left, we had to make some accommodations," Knoll allowed. "We elected to be consistent within each shot rather than try to match from one cut to the next. Once the cut sequence came down from the Ranch, we mapped the direction of sunlight for each element in a given shot. Often we would have identical north- or south-facing angles with totally different lighting directions, depending on the main-unit plate element lighting." Like the Theed miniature, the stadium was mounted on a rotating platform that allowed the camera crew to capture different sunlight angles.

Most of the ninety arena shots were digitally enhanced, to one degree or another. Among the CGadditions were 350,000 background characters in the viewing stands and on the track. These were handled procedurally by CG supervisor Habib Zargarpour. "Habib treated those characters as particles on a very base level," Knoll explained, "then exported them as primitives that could be loaded on the fly with animation cycles attached. These primitives possess something akin to intelligence – they know how fast the particles should move and realize where the character is within its walk or run cycle, due to particle run-time rules." Still, there were initial tracking problems in lining up the emitted-particle people with the miniature stadium's geometry for the duration of a given camera move. "Even with all of the motion

control data, these shots still needed a lot of finessing. Maya rules had to be tweaked to accommodate people walking up and down stairs, to keep them oriented along a desired path that was not flat." To create a ground plane for the starting grid area on the arena floor – against which pods and people could be added – dirt was sprinkled on plywood, photographed and scanned in for use as a texture map.

Digital crowd simulation, used in only six shots, was not the only means used to fill out the few extras filmed on location. For an extremely long view, the model crew dressed miniature stands with Q-tips painted different colors, hit with fans to provide minimal movement – although the footage was ultimately not used. Most of the visible spectators were provided by John Knoll, who produced a huge library of stadium crowd shots by shooting hundreds of extras – costumed by Annie Polland – on digital video at ILM.

Race preparations take place within the pod hangar, a full miniature set constructed by the model shop, into which bluescreen live-action and digital character elements would later be inserted. Key dressing for the miniature hangar included a number of race pods, each consisting of two jet engines cabled to a cockpit body. In all, the model shop built fifty-six units, ranging from thirty to sixty inches in length, used both as reference for hard-surface computer models and for set dressing within the hangar. “Good computer graphics require excellent reference,” stated Knoll. “With that in mind, I had the model shop build a lot of extremely detailed eighth-scale pod models to serve as lighting references, and from which textures could be generated for the digital flying pods.”



The cavernous pod hangar was represented by a miniature set dressed with pods and attendant racing equipment. Fifty-six individualized pods were built by the model shop and used either as set dressing or as reference for hard-surface CG versions. Doug Chiang and modelmaker Chuck Wiley dress the cables on a pod engine suspended from a ceiling crane within the hangar miniature.

The hard-surface modeling team built CG pods, with exterior details such as articulated mechanisms that controlled flight. “The pods had flaps and gears and actuators,” remarked Colie Wertz, “and some of those were actually built to work. We’d call the animators over in advance and give them a demonstration of what they’d be getting, so they knew what kinds of physical handles were available to them. Streamlined communications with the animators was the key in making these pods work in a way that was cinematic and credible.”

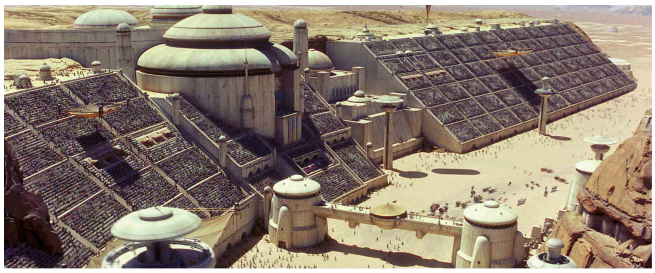
John Knoll and modelmaker Don Bies inspect a small pit stop set, built specifically for a scene in which an unwary pit droid is sucked into an engine on one of the pods.

Pod designs featured simple shapes, and as such required additional detailing that took the form of exposed workings within. “We got books filled with photos of jet airplane engine cowlings,” modeler Howie Weed recalled, “to get some idea of the hoses and wires and bolts and vents and blades that could go inside the engines, beneath the smooth surfaces. That gave us a starting point in modeling those stripped-down aspects that played up the drag-race roadster element in the pods.”

The pods are towed to the starting grid by a variety of animals, all of which were realized digitally. Some were familiar, such as the dewbacks and banthas seen in the first film, while others, like the eopies, were making their screen debut. “The dewbacks were all new and separate from what had been done for the Star Wars special edition,” stated Weed. “Alyson Markell did a bang-up job of modeling on that. She had some assistance from the art department, which developed a pseudo-anatomy for the creature. They provided a sketch

revealing details of the skeleton and musculature that defined which parts were cartilage; and this was used as a reference when we carved muscle lines into the creature model."

The camel-like eopies are seen in a number of sequences, including one that featured Qui-Gon riding atop one. "We had to match a bluescreen element of Liam Neeson sitting on a blue buck to the CG eopie loping along," recalled Howard Gersh. "It was a painful tracking experience, since the creature does a lot of dipping as it moves. We wound up splitting Qui-Gon's legs from his body and setting up another axis of movement beyond the usual left-right action in order to get the human character to move with the animal."



Anchorhead Arena revealed in a helicopter-style aerial shot. Rather than create the stadium digitally, John Knoll opted to shoot the daytime exteriors outside with an elaborate miniature.

Camera operator Bob Hill prepares for a motion control shot of the stadium model – which measured forty feet across and was the central feature of a much larger landscape model.

For main-unit scenes in Tunisia showing the vehicles being brought out, a number of full-sized pods were built by the production art department from military surplus parts. “The pods were supposed to be hovering,” Jack Mongovan stated, “so we needed to extract the wagons that main unit had carted them out on. Of course, when we eliminated those, it left every person on the far side of the pods with no legs, since the wagons had eclipsed them. We had to make up 2D legs for all these folks – a project that took six people two months to finish.”

While practical pod models were built for static, grounded views, digital versions were created and animated by the hard-surface crew for shots of the pods in flight. With a practical model for reference, 3D modeler Howie Weed fashions a pod in the computer. The CG pods featured an assortment of flaps, gears and actuators that the animators could articulate to suggest flight-control maneuvers.

In the screenplay, the mechanism by which the two engines of each pod are held together was identified as a ‘binder,’ illustrated as an electrical arcing effect. “The binder effect operates between the two engines,” Pat Myers related, “and is supposed to be a kind of electromagnetic spring – the harness for these wild-horse-like engines. To create the energy binder arc effect, we used geometry with shaders on top, desaturating the binder in certain environments to keep it from becoming distracting. Because it’s luminous but not entirely opaque, the binder arc was hard to read against a bright sky, so we benefited from the decision to show the effect against terrain much of the time.” Controls in Maya allowed TDs and animators to dial in the desired amount of electrical activity on the antigrav binder, controlling the frequency of arcing from frame to frame.

As the pre-race excitement mounts, drivers assemble beside their pods. Howie Weed, Sunny Wei and Alyson Markell were responsible for modeling many of these alien pilots. “There was Ben Quadinaros, who was something like Fatty Arbuckle,” said Weed, “and Gasgano, a multi-limbed spider version of Michael York from The Three Musketeers. Ratts Tyrell was our take on Joe Pesci, while Teemto was equal parts Nathan Lane and Dom Deluise, but with a certain bullying quality added.” The digital characters were designed with a heavy emphasis on paint. “Instead of modeling in every scale on a creature, we’d use bump and displacement maps to create detail. If you took away Ron Woodall’s terrific paint job, a character like Clegg Holdfast, as seen when rendered with a standard shader, would have looked like a bunch of sculpted tubes.”

Many of the drivers were represented on location by actors wearing masks and suits built by Nick Dudman’s crew; and in these instances ILM created CGcounterparts, then placed them inside the CGvehicles for the race. “Unfortunately, the creature designs never met the pod designs until they’d all been modeled,” remarked Weed. “The pods were open-cockpit jobs, but even so, some of these characters – like Mawhonic and Holdfast – were built with arms and legs

that were just too big to fit inside. One guy's horn might stick through something; or the big potato creature, Ben, couldn't reach his controls. So things got slid around on the pod models, and we did some cheats on the creatures – breaking their legs or other body parts – to get them nestled inside comfortably."

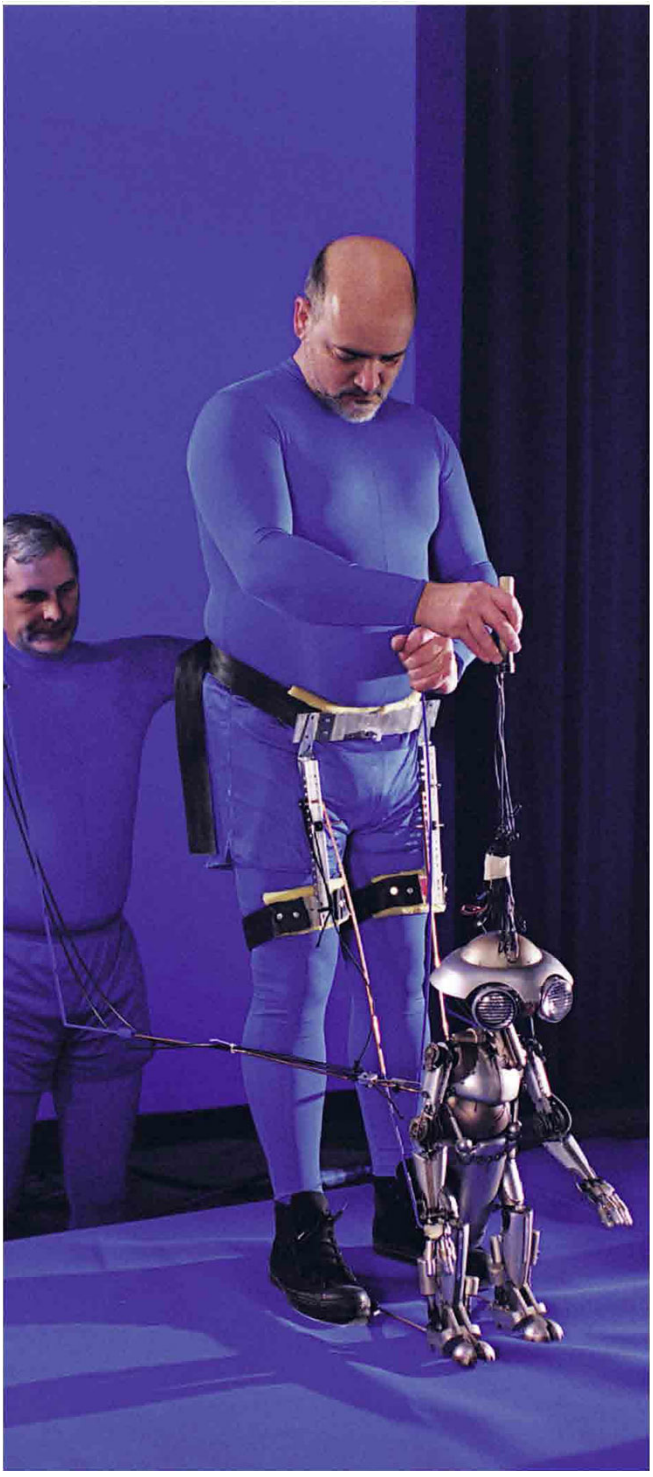
Another character introduced at this point is Fode/Beed, the two-headed creature announcing the podrace. The character, as initially conceived, was to feature live-action bluescreen heads attached to a CG body. "We thought this Death Becomes Her approach would work best," Doug Smythe said, "but after shooting the actors, it became clear that the amount of movement in the performances did not really jibe with the desired action of such a creature. A human neck is three or four inches, whereas this creature's two necks were much longer and very sinewy. It was difficult to get the live-action heads attached to the necks while simultaneously maintaining good animation on the neck movement – it just didn't look like it was all one creature. After several iterations we realized that it wasn't worth the effort and went to a full CG creature." Although the character was digital, its environment was not. Modelmaker Grant Sand contributed a sixth-scale set for the announcers' booth, as well as a VIPbox occupied by Jabba the Hutt.

As the race commences, most of the pods speed off into the distance, but Anakin's engine floods, delaying his departure. Finally, his pod revs up and the boy begins the first of three laps in a dusty traverse of Tatooine's arid desert expanses. The art department provided a map for the whole racetrack, which spanned a number of different environments. While the notion of generating the numerous backgrounds with aerial location photography had been considered, this approach was never implemented. Instead, some of the terrain was built as practical miniatures. Steve Gawley's model shop crew built a 1/72-scale representation of Waldo's Grade for a God's-eye view of the race, for example, plus a miniature of Beggar's Canyon that featured cliff dwellings within rock-wall crevices.

Other podrace backgrounds were wholly the province of CG, while a number of them combined CG and miniatures through a development pioneered in the digital matte painting department. The CG terrain effort began with CDs full of Monument Valley photographs shot by John Knoll. These geographic features were mapped onto geometries, but lighting conditions on the original photography curtailed their use. Consequently, a terrain development project was launched to generate a wealth of high-resolution imagery for utilization in tracking shots as the pods speed along at near-Mach speeds. The R&D department's Alan Trombla worked out terrain generation based upon groundwork laid by Zoran Kacic-Alesic. Beginning with a large description of the terrain – everything needed to address the high-resolution aspect – the system extracted only the precise amount of information needed for each frame being rendered, building patches of landscape in accordance with foreground control points.

"The idea was to create high-resolution terrain for the whole race environment, then load in only the portions we wanted to render," said sequence supervisor Dan Goldman, who worked on developing a pipeline for generating, lighting and rendering the massive amounts of terrain. "The terrain description consisted of several layers in addition to the basic ground plane. We employed the same shader for the high-resolution and the intermediate-resolution, so there wouldn't be any seams when the two approaches were combined. There were several different

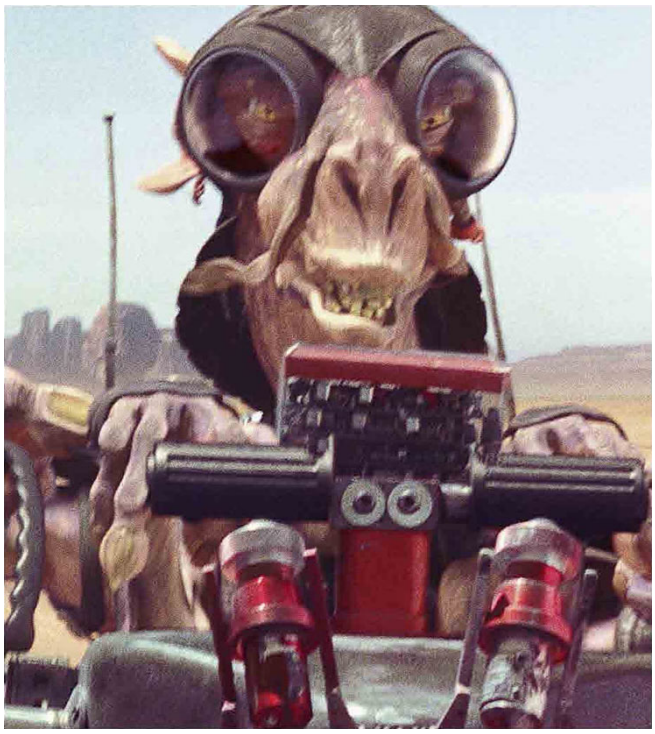
terrain styles, and we started with the least complex geometries – Hutt Flats and Droopy Drop – which were salt-flat and mud-flat environments."



Though all of the alien drivers in the podrace were digital, the sequence also had a number of composited puppet characters. Dressed in blue to blend in with the screen behind them, Scott McNamara and Mark Siegel manipulate a pit droid rod puppet on stage.

Other environments created via this terrain generation approach included Lagulla Cave, a stalagmite-encrusted passage, and a heavily cratered valley area. “The pods fly on an air cushion that can be disrupted by changing their proximity to the ground,” noted sequence supervisor Samir Hoon, “so the pilots have to swerve to avoid these craters. Every crater consisted of two images. The first was a black-and-white image defining the crater’s shape. The black areas indicated the measure of depression, while the white showed the flat aspect. Together they created a valley effect. This combined with the second image for each crater – a map of eroded and pitted detail – to form the whole crater.”

A principal art-direction issue involved the development of a realistic-looking color palette for the podrace environments. “We tried to match the Tunisia reference and found that didn’t work at all,” Dan Goldman recalled. “We had to come up with a new look that worked in context. John Knoll had decided the sun was due south, forty-five degrees above the horizon. But less than twenty percent of the shots employed that lighting scheme. Most of the racetrack wound up on a north/south axis, which would have meant looking either straight into the sun or directly into shadow. So we cheated the track to one side, so the sun raked a bit through frame rather than being directly south.” Views facing north were treated as a separate project, apart from the south-facing views. “When there was a whip-pan that combined the two, we had to blend between them. That approach was convenient for setting up terrain features. The dynamic range in exposure when we went from looking south to looking north was just so extreme – the balance between sky and ground changed in surprising ways, so we had to grade certain aspects so that our range conveyed the contrasts without distorting the overall environment.”



Digital characters in the podrace included arrogant champion Sebulba, Anakin’s chief rival and nemesis.

Driver Ben Quadinaros at the starting line. Podracers represented on location by performers wearing masks and suits were replicated digitally and placed inside digital pods.

The race vehicles consisted of a cockpit tethered to two separate jet engines, held together by an electrical ‘binder’ effect. The binder arc was created by applying shaders to digital geometry, with Maya controls enabling technical directors to dial in the desired intensity of electrical activity.

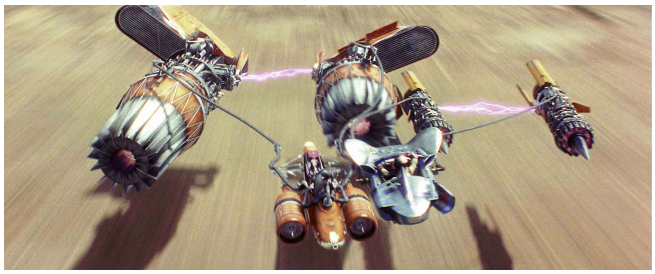
Digital’s attempt to create the podrace terrain in its entirety – essentially overproducing the environment – was foreign to the way ILM had worked in the past; and so, to produce about forty percent of the backgrounds, a new ‘digimatte’ approach incorporating both photographic and digital elements was devised by digital matte painter Paul Huston. While at work on the special edition of Star Wars, Huston had attempted to capture a new helicopter-style fly-up shot of Obi-Wan Kenobi’s Dune Sea home by building a practical model of the abode, then shooting it in a series of stills, each a bit closer to the subject. Huston then digitized the miniature and projected his photos onto the CG geometry, hoping to create a tiling effect with the series of images – one that worked three-dimensionally, allowing the camera to close in while accommodating the shift in perspective. “George thought the 3D aspect of the shot looked out of place with the rest of the movie, so it didn’t get used,” recalled Huston, “but I was interested in developing the technique further and got support for additional tests.”

Anakin’s pod approaches rock arch formations in the course of the cross-country race. Terrain for the high-speed sequence was created by building miniature sets, then shooting them from every angle to provide texture maps that could be applied to 3D geometries.

The tests included a flight through stone arches – quite similar to what was going to be needed for the podrace sequence. “John Knoll became interested in my approach,” said Huston, “and he supplied me with designs for the podrace landscape. While he was in England, I did some additional tests featuring a variety of different views – one started with a flying-forward motion, with the camera looking backward and then panning forward to look at the terrain that was approaching.” Huston’s tests met with enthusiastic approval.

Digital matte artist Paul Huston, who conceived the approach, works on a plaster scanning sculpture of one of the rock formations.

Model shop personnel were enlisted to begin the project by building detailed miniature landforms for Mushroom Mesa, under the art direction of Doug Chiang. These models, combining real rock with plaster and paint, were then taken into sunlight by Huston, who photographed stills from various angles, using an adjustable tilting rig built by Mike Steffe’s model shop team. “That setup let both the model and the camera be rotated,” explained Huston, “so the sun’s position wouldn’t be such a limiting issue. There were also measurement markers on the unit so we could do an accurate 180-degree move around the model. It’s much rougher if you have to just guess at the amount of movement while lugging a camera on a tripod around a model and shooting without these controls – especially when dealing with objects that are irregularly shaped like most of these. We could shoot 360 degrees of images, capturing the lighting at each different angle.” The series of still photos could then be projected back onto the digital model geometry, allowing for extreme perspective changes.



Intent upon winning, Sebulba attempts to bump Anakin’s pod out of the race, entangling the two vehicles in the process.

Many of these miniature landscape pieces were built, photographed and scanned, providing elements that could be mixed and matched digitally to create variety in the terrain through reuse and repositioning. “We’d compose each shot,” explained Huston, “swapping stuff around and changing certain features so it didn’t seem to be the same elements over and over.” From what initially was just a portion of Mushroom Mesa, the digimatte approach for pod environments would spread to encompass Arch Canyon, Tusken Turn and some of Beggar’s Canyon, with Jonathan Harb assisting Huston on the latter.

Live-action elements for the podrace included about thirty-five cockpit shots of Jake Lloyd, for which director of photography David Tattersall had set up a pivoting light rig to suggest

sunlight moving across Anakin's face. "Based on information about the area he was flying through and the direction he was headed, we would attempt to shoot our backgrounds to match," John Knoll remarked. "But George didn't concern himself too much with picking pieces that matched – instead he went for performance. So we would have to add little bits to make it all tie in. While he flies through Arch Canyon, Anakin passes these wicket shapes, so there needed to be some shadow interaction. A lot of that was done during the compositing phase by crushing highlights to darken the plate down." In a few instances, an all-CG Anakin was employed. "There were shots where it wasn't really practical to shoot a live-action element, or where the intent of the shot had changed since the original plate was shot. In those cases, we decided it would be easier to use a CG model rather than try to mash the plate to fit the new action." Other CG podrace scenes featured the actor's actual head, cut-and- pasted onto a digital body.

Anakin's pod required additional postproduction enhancement in the form of console display graphics inside the cockpit. More than 125 of these animated displays – usually seen from the driver's POV – were fabricated in the art department through the use of various commercial programs. "George told us that this was a grander period in history," explained David Nakabayashi, "so the screens and equipment look more ornate than they did in the first films. Most of the displays were a combination of 2D and 3D graphics depicting the conditions of a pod's systems and indicating its position within the environment. The screens were there to clarify aspects of the story visually and to create continuity – so figuring out the point of a shot was always the start for us."

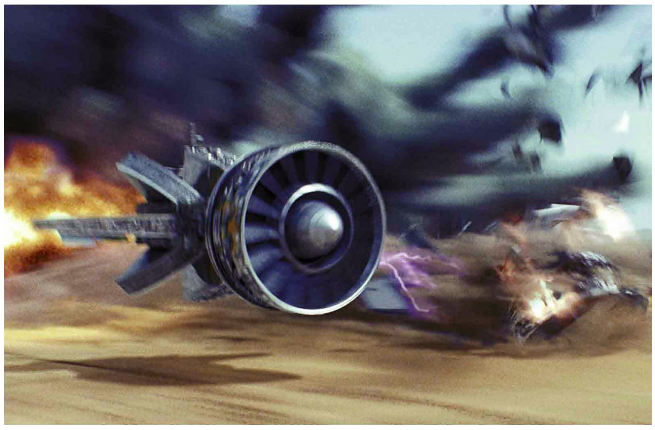
The system by which the pods were actually flown would go through an unusual development phase. "I built a full pod as a rigid CG model," recalled Habib Zargarpour, " and flew it using a procedural simulation approach – just to see what it would look like when we crashed it, since that was the aspect I was going to be involved with. John Knoll saw the results and realized it had a nice look that could be used for the flight shots, as well. The animators could have achieved the same feel, but this was a much quicker means to the same end. By using simulations – an approach I'm naturally a big fan of – you get happy accidents, surprises you don't anticipate."

The idea of using a procedural system for pod crashes proved so successful that the resulting system – based in large part on real physics – provided a solid underpinning to the podrace flight dynamics, animated by a crew under Peter Daulton, who oversaw the 160 podrace shots. "The pod engines were different from most kinds of spacecraft and aircraft," Daulton said, "since they didn't operate like a solid structure that banks as a single unit. The two separate engines are held together only by the binder effects – they want to be independent of one another – and are joined to the cockpit body by cables; so these pod elements could be animated as a whole or as separate en-tities. Any separation of motion between the two units created a springy interactivity that made their movement unique."

By allowing simulations to provide the gross flying maneuvers, the podrace animators – Melissa Mullen, Andy Wong and Chris Mitchell, with Dave Hanks and Andrew Grant joining the team later – could produce six to eight shots per week. Time saved by the simulations allowed the

team members to work on animating flaps and air brakes built into the pods, as well as to create personalized performance tweaks for each pilot.

For crash scenes, technical director Habib Zargarpour developed a dynamics simulation that created organic-looking debris and smoke elements quickly and efficiently.



Practical explosion elements were also incorporated into the crash composites.

Daulton was put in the position of overseeing camera movement throughout the sequence. “We tried to use reality-based camera moves,” Daulton explained, “moves that were similar to what a live-action film crew would use if one had actually been there photographing the race. The problem with a lot of CG camera moves is that they are too smooth or too extreme. Wild moves that no camera crew could duplicate read false to an audience. They know that it’s fake. For each of the podrace shots, we would decide where the camera should be, whether we should be following the action from a helicopter or camera car, mounted directly to a pod, or on a crane, dolly or a tripod. Then we animated the natural float and shake that the pan and tilt would experience if a camera operator were trying to maintain composition and follow action under extreme conditions. Audiences are accustomed to seeing action sequences photographed this way, and it heightens the reality.” Each pod’s passage through the desert kicked up a ‘rooster-plume’ of dust in its wake. Habib Zargarpour created the basic dust pass effect, with Chris White developing it into a Maya plug-in that TDs for the shots could bring up easily.

For closeups of Anakin inside his pod, Jake Lloyd was filmed against bluescreen in a cockpit mockup, mounted to a gimbal to simulate the craft in flight. Though stage lighting was sequenced to suggest the pod’s ever-shifting position in relationship to the sun, fleeting shadows and other enhancements were applied in postproduction during the compositing phase.

During the course of the race, many pods are eliminated in crashes – some due to pilot error, others due to villainy on the part of Sebulba, who takes on the mantle of Massala from Ben-Hur by tossing objects into the engines of opponents’ pods and engaging in a lethal game of bumper-cars with others. One of Knoll’s original justifications for building the eighth-scale pod models was that molds could be taken off of them as a means of casting up pyro replicas for the crashes. “I began to work out how fast we would need to move the pod and the camera,” said Knoll, “how much landscape model we would need to build, and how the rigs would have to work. It soon became clear that this approach was not possible without a major compromise in speed and/or shot design. At that point, I began to think that CG crashes were the best option.”

For the CG crash shots, Peter Daulton’s team, employing pod simulation controls developed by Habib Zargarpour and Chris Mitchell, worked out initial trajectories, then handed each shot over to Zargarpour and Chris White who would simulate the actual impact dynamics. “George wanted these shots to resemble car crashes,” stated Zargarpour. “We had lots of reference from NASCAR and Formula One races – and in real crashes, the cars kept tumbling and shredding as they came toward the camera, but they didn’t explode into big fireballs. So there was no heavy pyro to hide our effect behind – the pods had to crumple in full view, usually with the camera tracking alongside.”

Zargarpour installed the reference movie files – along with animatic footage – as shelf items in Maya so that they could be referred to during the modeling process. The movie files for the actual scenes would update each day as TDs continued to work on them, allowing everyone to work off the latest render. The pod disintegration effects were achieved by drawing metal tear designs directly onto the surface of the existing 3D pod models, using Maya. “Patches were

then assembled side by side on a single plane," said Andrew Cawrse, "and, using a custom patch deformation tool, were cloned and projected onto the surface of the pod models. The deformation tool allowed us to manipulate the single plane patches into their jagged tear shapes in 2D, which would update their projected clones in 3D across the surface shape of the pod. Employing this process, and some additional modeling, we deformed thousands of patches around the high-resolution pods, with the desired destruction being manipulated on a planar view in two dimensions, but executed in three. The effect could be compared to the animatic directly and serve as an editable means of approval for John Knoll."

Break-off – a plug-in written by Zargarpour, White and Hiromi Ono – allowed pieces of geometry to be scene-simulated at the speed of particle simulation. "Before Break-off was developed," Zargarpour related, "we were stuck with the limitations of Dynamation, which in preview form only let you watch dots move around. The advantage of selecting the actual pieces and deciding at which frame they'd appear was tremendous. Break-off controlled thousands of parts, directing when and where they would separate."

Due to the difficulties in performing true deformation on the pod parts, a different approach was required for certain shots. Zargarpour employed an airframe technique, using rigid bodies for collision. "I started with a pod hitting a pole and collapsing around it," said Zargarpour. "There were a number of rigid bodies pinned together, with the pod exterior enveloped onto that form. The actual airframe is modeled, with cross-springs added to create some plastic distortion. This is very visible when one pod crashes while traveling at six hundred miles per hour – the bottom of the pod pulls back with a shearing action at impact, crushing and folding up as it begins to tumble."

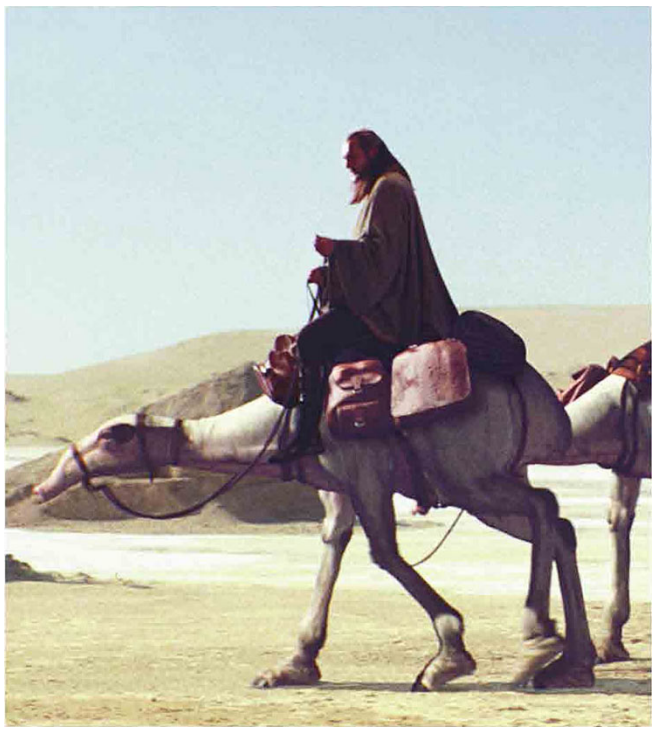
A deformation tool, Noisesculpt, developed by Eric Krumrey, allowed pod wingtips to be crushed incrementally on a frame-by-frame basis, and was employed to simulate ground trenches plowed by crashing race vehicles. "TD Russell Earl took on the deformation aspect when a pod hit ground," noted Zargarpour, "using Noisesculpt to carve the earth and form furrows of displaced ground. The size of these hills was determined by the combination of the pod's mass plus its velocity at impact." As a final sweetening touch, Peter Daulton would add some shake or image recomposition to crash shots, suggesting the presence of a camera operator following one aspect of the crash and letting other elements slip from view.

2D compositing supervisor Tim Alexander oversaw compositing of the podrace, a task that required his team to come up with a lot of tricks that would make the digital imagery more closely resemble live-action sports photography. "There were a lot of lens aberrations, chromatic aberrations and vignetting issues," Alexander observed. "We employed many compositing tricks to make the CG blend with the live-action."

Anakin and Sebulba wind up running neck-and-neck for the last half of the race; and the alien, intent upon dispatching the boy, rams his pod, causing the steering mechanisms for each craft to lock together. When the pods finally separate, Sebulba crashes into a rock while Anakin roars to victory. A shot of the young champion tossed in the air by exuberant well-wishers required replacement of the arena background when Lucas made an editorial decision to change the view. The new angle was obstructed by a crowd of about sixty extras – all of which had to be

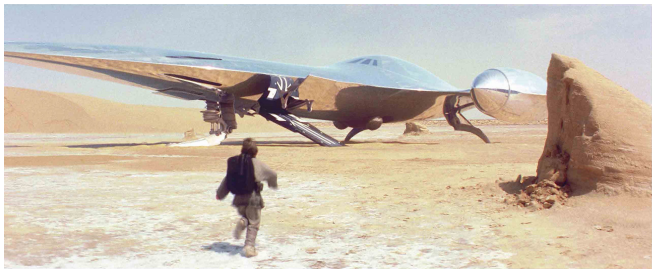
extracted by the rotoscope department. “This turned into an enormous roto effort,” remarked Jack Mongovan. “It was about three or four months’ work for one person to rotoscope those sixty people in the foreground. After we finished, John Knoll commented that it was a shame it had worked, since he’d never be able to get George to put up a bluescreen again.”

CG compositors Tami Carter and Eddie Pasquarello and CG supervisor Tim Alexander assemble a shot of Qui-Gon astride an eopie.



To capture the appropriate leg position and loping motion of Qui-Gon atop the animal, Liam Neeson was filmed on an articulated blue buck during the Tunisia location shoot. The rig was subsequently replaced with a digitaleopie, which had to be carefully tracked to the actor’s movements.

With Anakin's victory, the boy is freed from slave status and bids a tearful farewell to his mother and friends before leaving with Qui-Gon, who intends to seek the Jedi council's permission to train him in the ways of the Force. Its hyperdrive now functional, the queen's ship proceeds to Coruscant without further incident. Coruscant – the planet-spanning capital city of the Republic – would be depicted in a variety of architectural styles. "The queen's ship lands amid a Manhattan-style forest of buildings," observed Knoll, "but after that, at Senator Palpatine's quarters, you see structures that are older, with more of a gothic look, and everything is spaced out a bit more. Then there's the Jedi council tower in the middle of a wide-open area with even fewer nearby structures. In any major city, you can go a few miles and see completely different looks. George was very clear about wanting those same kinds of distinctions for various parts of Coruscant."



Freed from slavery on account of his podrace victory, Anakin runs to the queen's ship as it prepares to take off from Tatooine. Though in-flight shots of the highly reflective ship were realized digitally by the rebel unit, shots of it parked in the desert or other locales were achieved photographically with a ten-foot physical model.

The approach to Coruscant featured an elaborate cityscape surrounding a floating landing pad far above the streets, a vista produced by digital matte painter Yusei Uesugi, who created a wraparound view – essentially a snakeskin – of the surrounding cityscape. "This wraparound was assembled from overlapping views from several virtual cameras," Uesugi explained, "and it featured all thirty of the high- and low-rez buildings modeled for the environment. This view let me see where other buildings needed to be added, off-camera, so they would cast shadows across and onto buildings in the shot." Different angles in the sequence showed the structures – mostly new, although some were recycled from the Jedi special edition – from many sides, with shadows from flying craft passing over their surfaces.

As the queen's ship makes its final approach, Senator Palpatine (Ian McDiarmid), Chancellor Valorum (Terence Stamp) and other important officials can be seen on the landing platform below. A means of filming the figures, with the proper perspective shifts, was required. "The view changed drastically during the looking-down shots," Uesugi stated. "A live-action motion control rig could have performed this very big move on stage, but that kind of approach was too elaborate and costly – and we only had one day to shoot bluescreen and greenscreen elements for these dozen shots." Initially Uesugi tried to shoot the figures from a static position, somewhere in the middle of the intended camera move, but then a brainstorm struck. "I asked John to have the people walk in an arc rather than follow a straight path, and that allowed this change in orientation to be built into the live-action element. We made some fake shadows for the people, which went a long way toward tying all the elements together. John had said he'd use digital people if there was no other way, but this approach worked so well that his CG fallback idea never came up again."

To check lineup details on the live-action element and its CG background, Uesugi rendered a magnified view of the figures – basically creating a long-lens view. "I spent a week eyeballing the shot," commented Uesugi, "massaging elements to prevent the figures from slipping during

the perspective change. During this time, I started to fall in love with this telephoto view, which had a nice documentary feel. When we all realized that this closer view explained the visual situation more clearly, I softened up the focus on the background and the shot became a part of the show – in fact, it's one of my favorite shots."

Uesugi's technical assistant, Douglas Applewhite, developed a software solution that allowed digital matte painting environments to be unwrapped so they could be projected cylindrically. Rick Rische would use the Applewhite program for a later Coruscant sequence that featured a digital cyclorama showing the view through the windows at Palpatine's quarters. "Huge amounts of color correction and tracking were required for the Palpatine backgrounds," recalled Saber artist Rita Zimmerman. "The scene occurs over a period of time, so the matte painting had to transition from a beautiful purple dusk to a blue darkness, which required gradual adjustment to the plates."

A view of yet another part of Coruscant was revealed earlier in the movie, during a night scene in which Darth Sidious converses with his apprentice, Darth Maul, on a balcony. "Paul Huston did those paintings," John Knoll stated, "and while he was able to draw a bit from Yusei's work, the architecture had to look different. The building needed to be darker and gloomier than those in other parts of the city, and that stylistic difference was entirely deliberate. Paul worked from a Doug Chiang skyline design, first building CG models, then making a render pass and doing additional painting on top of that."

Queen Amidala makes her way to the galactic senate chamber, while Qui-Gon and Obi-Wan present young Anakin to the Jedi council within the Jedi temple. The temple was another digital matte painting, while the council chamber interior was a practical set built on an elevated platform at Leavesden to accommodate the puppeteering of Yoda and other nonhumanoid Jedi created by the Nick Dudman team.

The senate rotunda, which fell to the Squires unit, was one of the production's most ambitious self-contained virtual environments. Built by Andrew Cawrse and Ed Taylor, the rotunda was designed as a domed stadium – a vast, hollow space with curved walls into which individual flying delegate boxes were docked. The boxes – dubbed 'pods' – could detach and float to a central podium whenever a delegation wished to address the assembly. To model the vast space, more than a hundred structures were created in three resolutions and repeated in a 360-degree sweep. "The three different resolutions of geometry were based on distance to the camera," Cawrse explained. "We used basic trigonometry to figure out the exact angles and circumference of each wall section so it would align perfectly when repeated, while maintaining matching spans for paint replication." Though portions of the chamber set had been built at Leavesden to accommodate the filming of live-action scenes, ultimately the whole set was rendered in CG.

From Tatooine, the group proceeds with haste to Coruscant, the government seat of the Republic, where Queen Amidala intends to plead Naboo’s case to the galactic senate. Digital matte paintings of the planet-city included views of the Jedi temple.

When the queen’s ship sets down on a landing platform in the city center, its passengers are greeted by a welcoming delegation. Matte artist Yusei Uesugi combined a digitally painted cityscape and platform with live-action elements of costumed extras.

One of the questions at the beginning was how to produce the delegations assembled from every corner of the Star Wars universe. The rotunda walls were designed to hold more than a thousand pods; and although as few as six hundred would be in view in any given shot, it was still a considerable number. Although the pods would be computer generated, it was decided not to integrate CG aliens but rather shoot live-action elements of costumed actors. Dozens of alien delegates had already been created by the Dudman team and filmed during the main-unit shoot, but a great many more were added later at ILM. “We shot greenscreen digital video for those,” said sequence supervisor Steve Molin. “It was faster to move costumed extras through, it took fewer people to move the camera, and it was appropriate to the level of detail we needed. Those close to camera, requiring more detail, we shot on film.”

While in Coruscant, Qui-Gon presents Anakin to the Jedi council, seeking permission to train the boy as a Jedi knight. An elevated interior set at Leavesden facilitated the puppeteering of Yoda and other puppet-based council members. Bluescreened window areas were later filled in with matte-painted skylines and flying vehicles provided by the rebel unit.

To emulate the hustle and bustle of a political gathering, extras were shot in a variety of poses, with some milling about, others talking to neighboring delegates, but most paying quiet attention to the proceedings. The shooting setup was simple, with a greenscreen backing, green boxes for the extras to sit on, and a green-painted plywood turntable. With the turntable capable of rotation, Marty Rosenberg and his crew were able to shoot from five different positions using four digital cameras at the same time. Each delegation was comprised of an average of three costumed extras, though resources were often stretched by filming a single person in multiple positions to account for a full pods’ worth.

The delegation shoot stretched into four days and produced a staggering number of elements that were culled through and used as needed. “We shot four thousand different elements,” recalled Rosenberg, “about thirty-two hours’ worth for a three-minute sequence.” To place these elements into computer generated pods, Molin mapped out the 3D space and accounted for virtual camera angles in the rendering stage. “Instead of rendering the rotunda and then compositing the people in place with mattes and rotoscopes,” Kevin Rafferty commented, “we took the elements and pre-processed them, basically texture-mapping the live-action footage onto a flat piece of geometry we placed in the pod. That way, the elements became part of the render, not part of the composite.”

In addition to the background delegations, there were hero bluescreen elements of live-action pods that had to be moved in 3D space. With Lucas’ mix-and-match approach, the director could opt to roto out the practical pod performers and insert them into a CG pod, even reconstruct a scene with borrowed bits and pieces. “On this show,” related Scott Squires, “George basically treated things in editing as his virtual camera, going through and saying he’d prefer the box flying in another direction, for example. In some cases he had photographed a pod breaking frame, then later wanted to use that element reduced into the scene. With part of the platform

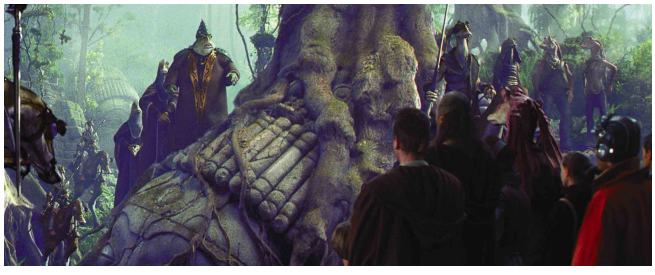
cut off in the original photography, it was easier to rotoscope out the people and put them in an all-CG pod."

Downstream from assembly of the rotunda elements was the rendering. In the RenderMan file format describing an image's geometry, lights and shaders – termed an RIB file, for RenderMan Input Bytestream – every piece of geometry is normally accounted for. But with virtual environments, normal memory and rendering times zoom off the charts, making it prohibitive to put all of the geometry into an RIB file. A RenderMan update was required to deal with the geometry-heavy environments in The Phantom Menace. "What Pixar added to its RenderMan system," explained Molin, "was the ability to put in 'place holders' – which are replaced with whole, pre-generated RIBs at render time. The advantage there is that only the geometry of interest is evaluated." The RIB package also allowed for multiple lights playing off the rotunda pods, an effort spearheaded by Philippe Rebours. Making shadows was another computationally daunting aspect of the rotunda's creation. "A 'shadow buffer' is the creation of shadows, which are usually generated every frame," explained Kevin Rafferty. "We worked with our software department to jumble our scripts and make modifications to speed things up, making it possible to reuse single shadow buffers on multiple frames."

Although the initial intention was to use only costumed extras for background shots of the senate chamber, the character animation team was called in toward the end and asked to generate some nonhuman characters, for variety. "We didn't have to do any of the hero shots with characters giving speeches and such," noted Rob Coleman. "All of our shots were for the background – so it wasn't really difficult animation. If you look at a room full of senators, no one's actually doing much. One might be moving his head or shuffling his papers; one or two might be sleeping. The same was true for this sequence – there wasn't that much animation required. The most difficult part was keeping it subtle, which meant that at times I had to rein in some of the new animators. It was natural for them to think: 'Oh, boy, I'm doing a shot in Star Wars!' So they would go into it wanting to give it their all and create this fabulous, over-the-top performance for their character. My job was to make sure they only did what was appropriate for the shot."

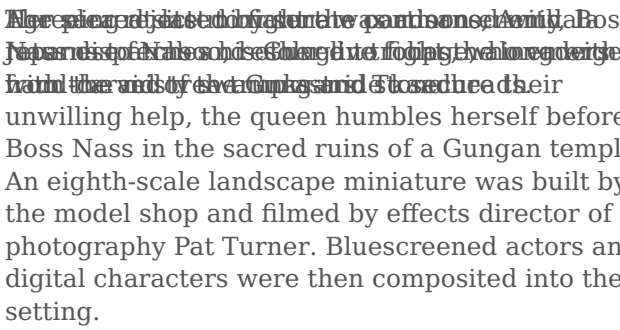
Queen Amidala's plea to the senate prompts only bickering and indecisiveness among the delegations. With little hope of help, and fearing for her people, the young queen determines to return to Naboo and face the invaders on her own.

ACT 3



Upon returning to Naboo, Queen Amidala discovers that the invasion has intensified; and, recognizing that her subjects are helpless against the marauders, she determines to seek out the Gungans for aid. But when Jar Jar swims down to Otoh Gunga to approach Boss Nass, he finds the city empty, and postulates that his people have

moved to a ‘sacred place’ in the swamp – a ruined temple of ancient Gungan civilization.



Plates depicting Qui-Gon, Obi-Wan, Jar Jar, Amidala and her entourage moving through the forest toward the sacred site had been photographed in Whippendell Woods in England. It was up to Dennis Muren’s team to marry that live-action footage to a miniature swamp set, built to represent the sacred place and populated with computer generated characters. “The swamp set was built in eighth scale,” stated Steve Gawley, “and measured forty feet deep, twenty feet wide and fifteen to twenty feet tall. It was made up of tree trunks and rocks, with big carved stone heads placed among them. Tree trunks were made out of rigid urethane foam, hand-carved and painted by Lorne Peterson and his team; and we also used greenery from nurseries – Japanese ferns and miniature ground-cover plants. There was supposed to be a pond, too, which we simulated by laying down plexiglas. Since the shots were from a low angle, light reflected off the plexiglas and it looked fine.” Pat Turner shot the set, capturing both still photographs and motion control footage, depending on requirements of the scene. “Then it was enhanced digitally, with little swamp creatures, water movement and digital characters. It looks totally convincing in the final film.”

One of the challenges of the sacred place was marrying the lighting of the live-action forest footage – which had been shot in normal daylight – with subsequent miniature composites of the temple ruins. “We wanted the shots of the sacred temple to play very magically,” noted Christopher Townsend, “with mist, God rays and dramatic lighting. We wanted to create an almost fairy-tale environment – but lighting of the forest shots leading up to it was relatively stark, and there was nothing particularly magical about it. So to marry the very realistic live-action plates to the mystical temple shots was a challenge. We used other shots to bridge the two – scenes with less fog and less backlighting – so it wasn’t such a jarring transition. But it was still quite a feat to find the balance between the two environments so they would blend in the final sequence.”

A massive Gungan army is assembled when Boss Nass agrees to help the people of Naboo. That army meets up with the droid army on the hills and plains of Naboo in true Braveheart and Spartacus style. Shots for the ground battle – Dennis Muren’s second big sequence – did not begin moving through the production pipeline until just a few months before the film’s release. “Technically,” explained Muren, “the problems with the ground battle shots were figuring out how to get them all done in the time-frame we had, and how we were going to get the performances needed for the hundreds and thousands of characters that made up the Gungan and droid armies.” Other challenges were that the battle had to take place in broad daylight, and every element – every character, every creature, every prop and weapon, even the ground on which the armies traveled and the green hills in the background – had to be either computer generated or, at the very least, computer enhanced.

Of the nearly 150 shots in the ground battle, only ten would feature moving backgrounds. For the remaining, static backgrounds, Muren went out to the hills east of ILM’s home base in San

Rafael and shot still photographs. “We joked about how we had been trying to get Dennis back on stage to shoot elements for years,” related Ned Gorman. “I don’t think he’d shot an element since Empire Strikes Back. So for him to go out and shoot all of the plates himself was somewhat momentous.”

“We shot hundreds of stills,” Muren added. “Then we started pasting them together to make our backgrounds. It was all the sequence really needed. You wouldn’t see the grass blowing in most of the shots, for example, because the camera was far enough away. This solution also allowed for ‘the George factor’ – it allowed him to change or add shots because we were not locked into a live-action plate.” The stills were scanned, then assembled and tweaked in the digital realm. “Every part of the plate was constructed, from the color of the hills in the background to the amount of tearing in the grass after the armies march through. If we’d gone out with a crew to shoot these things, even as empty plates, we’d still be shooting them – and the result wouldn’t be as good. This way, we started with what just barely worked, then fixed it up as we went along, putting more elements into it, adding the appropriate camera movement, and making it better and better.”

A distortion that gave a somewhat otherworldly look to the hilly backgrounds was actually the result of a happy accident that occurred a full year before Muren and Gorman joined the show. “Some of our guys had gone out to this same area and shot running footage, with the idea of using it for the battle,” Gorman recalled. “Later, we were reviewing the footage in our theater and the the wrong lens was on, so we were seeing the hills compressed and squeezed. The projectionist said, ‘Sorry, I’ll put the flat lens on.’ But then our coordinator, Vicki Engel, pointed out that it looked kind of neat like that. The hills were squeezed, which made them look a little strange – very pointy and impossibly narrow. So we did the same anamorphic squeeze on the backgrounds assembled from Dennis’ stills. The result is a landscape that you believe could be found on Naboo, rather than the Central Valley.”

The massive Gungan army assembles on the plains of Naboo to do battle with invading Federation droids. To create static backgrounds for the ground battle, Dennis Muren shot still photographs of hills and sky, which were then digtally tweaked and tiled together.

Into those photo backgrounds were composited both digital imagery and models, such as sixth-scale hero tanks and pyro-technic replicas. “The hero AAT had practical guns, articulated by solenoids,” Steve Gawley elaborated. “It also had a revolving turret operated by an electric motor. The main gun recoil was activated by an electric solenoid, as well.”

To supply a lot of tank footage to choose from in assembling the final shots, Ray Gilberti shot the practical tank models outdoors, from a variety of angles. “Those were for shots of tanks just sitting on the battlefield or moving in the distance,” noted Pat Sweeney. “If we had a wide shot of, say, six tanks coming over a hill, Ray would take one MTT or AAT model and shoot it, then move the camera off to the side and shoot it again. Because he shot all these different angles, a single tank could be used to simulate six in the final composite. We couldn’t do that for all of the shots – such as those in which a tank had to do a specific move that would change its perspective. For those, we shot the model with motion control on the stage. Dennis was very particular about matching stage lighting to the footage that we shot outside.” In addition to the typical beauty pass and matte pass, Sweeney shot a shadow pass that would aid the compositing team when it came time to assemble the model photography elements with the tiled backgrounds. “They could throw that shadow pass up on a hillside next to a tank. Also, since in the ground battle the tanks are moving up a green field, in our beauty pass we would have that approximate color of green reflecting back onto the tanks.”

Sequence supervisor Christophe Hery studies a shot of the computer animated Gungan army. All of the Gungan soldiers were modified versions of the Jar Jar computer model.

Gungan forces shield themselves from battle droid laser fire by directing a beam from an energy shield generator toward a device that creates a protective dome above the troops. Hard-surface models of the shield generator units were mounted on the backs of fambaas created by the character animation group.

Aside from these model elements, the ground battle would be achieved entirely with computer generated characters, vehicles and weaponry. Ken Bryan of the hard-surface model team built a Gungan battle wagon model, for example, while Andrew Cawrse built the catapult used to fire energy balls at the droid enemy. As in all the Gungan art nouveau designs, the curved lines and elaborate details of the weaponry complicated the model viewpainting, executed by Ron Woodall, who would be responsible for painting both the Gungan and the droid armies. “For the battle droids,” said Woodall, “there was one base color map, then five distinct paint schemes

with dirt and dings and such that could be mixed and matched to make many different versions. The TDs set it up so that the computer could take those various maps and interchange them randomly throughout the hundreds and hundreds of characters."

Computer animation of both the droid and Gungan armies was guided by animation co-supervisor Tom Bertino, who came on to the project late in the day to relieve the seriously overburdened Rob Coleman. "Rob still had the overall say," Bertino acknowledged, "but he pretty much trusted me to supervise the ground battle animation and keep to the look that had already been established."

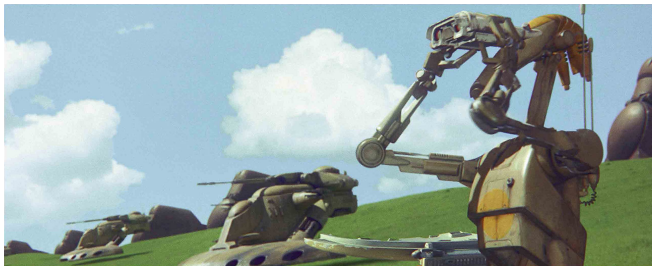
The sheer number of characters sorely complicated the animation task. In some wide shots, literally thousands of droid and Gungan soldiers would be revealed on the battlefield. For the ILM animators, accustomed to working mostly with hero animation involving only a few characters, the computer animation of the ground battle masses was a whole new situation. "Having animators work out performances entirely is manageable if you have just a few characters, such as in Jurassic Park," remarked CG supervisor Christophe Hery, who was instrumental in developing animation and rendering approaches for the ground battle. "Even a large number of characters is manageable if you can handle them through motion paths – as was the case with the groups of fifty or so characters in Jumanji or 101 Dalmatians. But the ground battle presented a whole different problem because we were dealing with literally hundreds and thousands of characters."

Since neither a path approach nor hand-animating was feasible for that many characters, a new tool had to be developed to handle crowd animation. "There were two sides of the tool," Hery observed. "One was the choreography part that controlled and animated a huge number of creatures. The other enabled us to render that tremendous amount of data in a timely manner." Animators developed cycles of action and character performances in Softimage and in Caricature, as usual, but then that animation was laid out in Maya. "It just so happened that Maya was the perfect tool to use for the ground battle animation because its scripting language gave us high-level control of the crowd. To lay out several hundred characters, we couldn't afford the time to draw a path for each one – which is what we have done in the past. It would be too much for the animators, and it would be difficult to check and make sure there was no intersection of characters or things of that sort. We needed a more global view on our group of digital extras. We needed to be able to say, 'Of these five hundred droids, ten percent will be walking, twenty percent will be running, thirty percent will be aiming their guns and shooting' – and then let the computer randomly position them and assign those actions. But the animators created all of those actions to begin with, so it wasn't procedural animation. We had an entire library of cycles and actions, created by the animators, to choose from."

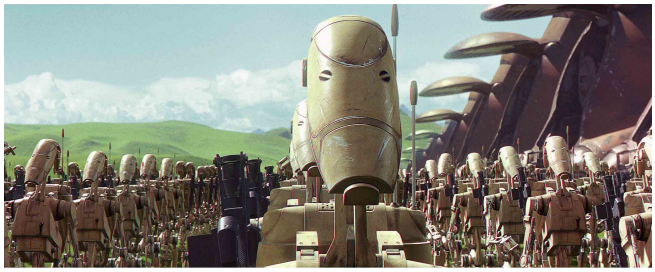
"There were all kinds of different behaviors for both armies," stated sequence supervisor Michael Di Como, who oversaw the ground battle choreography, "running, walking, dying, shooting, flinching, et cetera. There were Gungans throwing energy balls on foot, Gungans on kaadu, Gungans and droids in hand-to-hand combat. Picking and choosing from the palette of animation, we'd choreograph a shot, plopping down thousands of characters onto the 3D ground plane. Then the computer randomly chose from all of the attack cycles and assigned them to individual characters. We could also group things, putting the cavalry guys behind the

infantry, for example, or have one section run towards a goal while another engaged in hand-to-hand combat. The computer would do its random selects, but then a choreography TD could go in and get specific, and tweak things. Every shot in the battle had hero animation, as well as the computer choreographed animation. Dennis or George would look at the random stuff the choreography TD had done, then say, 'Okay that guy over on the right – let's have him get shot and die on this frame.' And since we had control over the animation of specific characters, we could do that. That was the power of this system – we had control over what we wanted to control, but we could rely on the computer to do the other stuff."

The animators also had tools, written by Hiromi Ono, that enabled them to previsualize what the final shot would look like once all the choreography had been assigned. "We could pre-visualize our shots in real time through Maya," Hery observed. "So if Dennis said, 'I don't like this creature here; I want it over here,' we could address those changes immediately. Basically, it amounted to a whole second stage of choreography. The animatic from the Ranch guided us for the first pass of animation; but then we did a second stage where we refined the shots."



A battle droid commander scans the horizon as hordes of armored attack tanks and troops move into position.



Literally thousands of battle droids would be featured in the ground battle sequence. To expedite the animation and rendering of such a vast number of characters, ILM's research and development team devised new digital tools. One enabled animators to create a library of martial activities – such as marching, running and shooting – then let the computer randomly assign those actions among hundreds of combatants.

Although animation cycles greatly simplified the animation of such a large number of characters, they also presented the potential for shots that looked cyclical, without the random nature of real live-action footage. "If you're out shooting a real war scene," Muren commented, "and you've got seven cameras going and you shoot a take that runs for two minutes, somewhere in all of that will be a great four-second take from one camera and another great few seconds from another camera. A lot of things will come together randomly – accidents even – that will give you those great four seconds. It's a very different thing to say, 'We're not going to shoot for two minutes; we're just going to create those great four seconds' – which is what we do in a CG shot. There are just too many spontaneous things that have to come together to create a great shot; and we don't have that element of spontaneity in CG. So I feel that there's a certain amount of magic you miss when you're working with animation cycles and libraries.

"The other problem is that the more characters you have, the worse it looks. We use a cycle for one character, and it looks great. But then you get a second character in there, and you start to see a pattern in the animation. So you tweak that one and make it look more random, without the pattern. But then you put a third character in, then a twelfth, then a hundredth – and you

have something far beyond what the medium can deal with in terms of making each of those characters look random. The more characters in a scene, the harder you have to work to get rid of the patterns and make everything seem real."

In addition to the behavioral cycles created from scratch by the animators, some animation for the ground battle and other scenes was created through motion capture technology. "We did quite a bit of motion capture work," noted Muren, "because we had so many characters to animate and only so many animators at our disposal. Many of the droids battling and walking were done with motion capture; and a lot of fighting Gungans were motion capture, as well. It was used throughout the show – for both foreground and background characters – and it was a very fast way to create animation, but it still took a lot of time and effort to clean it up sufficiently."

Motion capture involved outfitting a performer in a suit that had marker balls at all the major joints, then recording the individual as he went through a series of moves and capturing that data on the computer. While, typically, five to seven cameras are used to record and capture the movements of a motion-capture performer, up to twenty cameras were employed in The Phantom Menace sessions. "The more cameras you have around the room," explained Jeff Light, who first set up a motion capture system at ILM in 1996, "the more angles you can see and the more data you have to work with. Each camera would see a bit of the action, and that data could then be triangulated to create the three-dimensional volume."

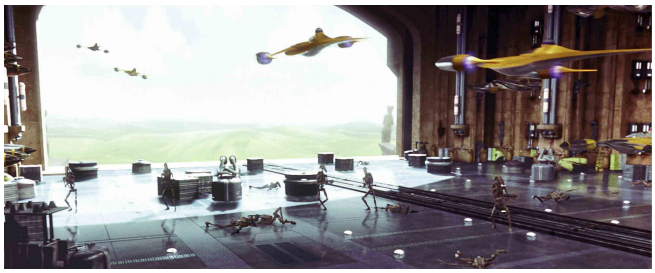
The Phantom Menace would mark ILM's first major venturing into motion capture – in tandem with its work on The Mummy – and, after evaluating several systems, the company selected Oxford Metrics' Vicon 8 system. Vicon's own plug-in allowed the exporting of motion capture data and skeleton files to a format usable by character animators; but typical optical capture problems still arose, necessitating the creation of a new ILM proprietary tool. "Data points can get obscured," commented Florian Kainz, "as in situations where hands are folded over the chest, causing chest data markers to be blocked. So John Horn came up with Mojo, a tool that allowed the data to be cleaned up and noise eliminated through the detection of problems within it. If the inside of a wrist is missing because it has been obscured, this data can be recovered from other points, based on knowledge of spatial relationships. Mojo works either interactively or automatically, with a rule-based intelligence."

Jeff Light, who was skilled at mimicking Ahmed Best's Jar Jar movements, was often used for motion-capturing members of the Gungan army, while James Tooley was the source for battle droid captures. "We were in the suits more than anybody," remarked Light. "James had a tighter, more mechanical way of moving, which was good for the droids, while I was able to do the looser Gungan moves. Between us, we got most of that stuff captured. If a pickup shot was needed, we could run over to the motion capture stage, capture a few moves in an hour, process them and have them in the shot the next day."

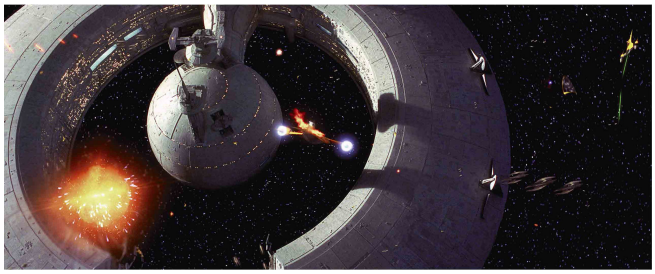
Also instrumental in the motion capture sessions was Tom Bertino. To provide some Gungan and droid animation for the ground battle, Bertino was himself motion-captured while performing a variety of actions. "Traditionally," said Bertino, "animators recoil from motion capture like a vampire from garlic – but it was a real revelation to me. For the proper applications, it's a

wonderful tool; and since our system is in a constant state of improvement, it's only going to get better."

Bertino would also direct many of the capture sessions with Light and Tooley. "Tom would say, 'Okay, this is a soldier who's been walking for the last twenty miles and he's tired,'" recalled Light, "and we'd do that kind of walk. Then he'd give us a different kind of walk to do. We could get those kinds of subtleties in the performance immediately, whereas to animate something like that, with that level of subtlety, would have been very dif-ficult and time-consuming. With so much other character work to do, it wasn't worth taking our best character animators and having them spend their time getting droid performances for an army scene." Once a performance had been captured, a certain amount of cleanup was still necessary to bring the data up to the desired level of animation. For that purpose, John Horn devised a feature in Mojo that enabled motion-captured takes to be blended, so that a walk cycle could transition smoothly into a run cycle, for example.

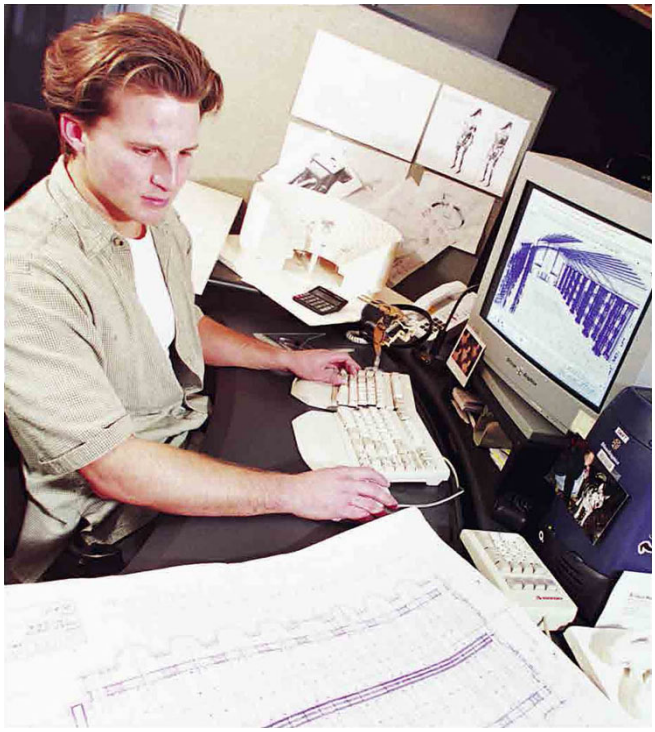


The land war is extended to space as Naboo starfighters take off from the Theed palace hangar. A partial hangar set was expanded immensely with digital set extensions. Shots of starfighters in flight were produced by the rebel unit.



A monumental space battle between Naboo and Federation starfighters is waged around the Federation battleship – the nerve center for the droid army.

While motion capture was the perfect technology for capturing basic walks, runs, and generic battle poses, certain actions were too dynamic or dangerous to be executed by a performer linked up to the system. "There were things we couldn't do with motion capture," admitted Tooley, "because of the limitations of the space, for example, or the limitations of what even a stunt performer could accomplish. So we would have to either blend into key-frame animation for those things, or go into some sort of dynamic simulation."



The problem of rendering the huge number of characters for the ground battle was solved with a RenderMan feature called 'level of detail.' "Level of detail allowed us to determine how much detail should be on a model, depending on how far from camera the character was," related Christophe Hery. "If a character was far away, there was no need to carry a lot of geometry – a simpler version

of the model would be sufficient. Another feature was ‘procedural primitive.’ Instead of communicating geometry to RenderMan, we took the opposite route. We would tell the system: ‘You need to render a droid at this position. Go and get the geometry for those pixels.’ And the renderer would decide what data it needed at any given time. In the past, if a creature was not in view of the camera in a particular shot, we had no way to tell the renderer not to load that geometry. But with this approach, if the geometry wasn’t in view, the renderer wouldn’t load it. We saved a lot of memory that way.”

A Gungan model by Andrew Cawrse, built to be used as the basis for the computer model, pictured by model maker Jason Dutra.

In the course of the battle, the Gungans use an energy shield generator – mounted atop a giant beast called a fambaa – to provide their army with a temporary protective shield through which enemy droid laser fire cannot penetrate. A beam from the generator is fired into a large dish on the back of another fambaa, causing an umbrella-like defensive screen to form overhead. For shots of the shield generator being blown up by the droid army, the model shop constructed a sixth-scale generator model. “It was almost four feet in diameter and three feet long,” said Steve Gawley, “and it was made of very lightweight urethane foam so that we could blow it up easily. We built only one finished model, but we gave Geoff Heron, our pyro lead, a number of unfinished ones so he could practice with them. We had two cameras on the hero generator when he blew it up.”

The Gungan energy shield itself was a piece of 3D geometry that would prove to be one of the movie’s stickiest aesthetic problems, requiring considerable tweaking in the final months of effects production. “The energy shield is this big membrane that protects the Gungan army,” said David Nakabayashi, “and it is supposed to look something like the protective membrane in the bubbles in Otoh Gunga. We went for something very simple, to start – essentially a pink dome – but that evolved into a more bubble-like structure. For scale, we added little cell structures to the membrane.”

Christophe Hery wrote the shader for the transparent energy shield. “Then we had to ask ourselves if we wanted to actually model that structure or if we wanted to find a procedural way to get that look,” remarked Hery. “In either case, the problem was how to make it look as if this static image was moving. What would happen to The Cells as the shield moved? I thought it would be great to see them recede in time, then appear again. The shield had an organic look, as opposed to something that looked like stiff geometry.”

Refinements made The Cells appear both transparent and reflective – a difficult balance to achieve. “When you are dealing with a transparent object like the shield,” Hery observed, “it is the surrounding environment reflecting on the object that defines it more than anything else. So we had to play around with the amount of reflection for each shot, as well as the amount of refraction and transparency, and the color we wanted the sky or the clouds to be behind it. The basic look was provided by the shaders, but a big part of it still had to be worked out by the compositing team and the TDs, on a shot-by-shot basis.”

“We couldn’t really finalize the look until it went into the compositing stage,” agreed 2D composite sequence supervisor Dorne Huebler. “We went back and forth between Christophe

developing the shader and me working to see what we needed to change in the renders once they were integrated into the composite. There were many issues with the shield: the speed of the animation, how much displacement it should have, and the balance of transparency so it looked as if it was being hit by light and reflecting it, but also letting light pass through. From a story point of view, we needed to show that this shield was protecting the army; but on the other hand, we had to be able to see through it so it wouldn't obliterate characters on the other side." Two different renders were created and manipulated in the composite so as to achieve the right balance in the energy dome. "One render was The Cells wrapped around the surface of the overall dome, and the other was an electrical look between those cells. We had to be able to treat those differently and manipulate them separately – so they were separate renders. We also had to make it appear as if there was interaction as the dome touched the ground, which was done with a slight color shift and a fire-like energy interaction."

Other elements composited into the ground battle consisted of practical explosions executed outdoors against bluescreen, by Geoff Heron. The outdoor venue provided natural sunlight – as it had for all the exterior model shoots – but it made compositing of the elements more difficult. "A lot of the model and bluescreen work was shot outside for this show," remarked Jon Alexander. "You get so much for free that way, if the sun is in the right position, but it makes it more ambitious at the compositing end in terms of trying to pull extractions. Ideally, we like to have a very even blue all the way across – but that's just not practical when the yellow sun is lighting up a blue canvas backing. Also, the canvas has seams in it, since it's so big, and that makes the blue uneven. As a result, we have to do extractions one area at a time. We do one area, move on to the next, and then use the computer to put them all together."

Bright daylight conditions complicated every aspect of the ground battle sequence – not only compositing, but rendering as well. "It is very expensive to render something in bright daylight," asserted Hery, "because it requires a lot of light to sim-ulate bouncing effects from the ground onto the creatures and objects. But since rendering time is directly proportionate to the number of lights and their shadows – and we didn't have a huge amount of time – we compromised by using only five or six lights, cleverly placed to produce bounce light on our creatures. We put in a very strong illumination from the key light – which represented the sun – then two secondary lights from the sky, and then some bounces from the ground."

Throughout, Dennis Muren strove for a sense of realism in the essentially all-CG ground battle by incorporating stylistic idiosyncrasies common to film. "Dennis is great at matching the imperfections of filmmaking in CG shots," related Christopher Townsend. "He understands that camera moves aren't always perfect. Sometimes the camera shakes a bit, or there are chromatic aberrations, or there is lens distortion. All of that makes real film look different from beautiful, pristine CG. So Dennis makes sure those kinds of imperfections are included in the CG shots – and it adds a tremendous sense of realism."

While the ground battle rages, a raid on the Theed palace results in the liberation of several Naboo starfighters, which Amidala and the Jedi hope can successfully engage the Federation battleship orbiting overhead that serves as a control center for the droid ground forces. Anakin hides in one of the spacecraft and inadvertently takes off along with the resistance fighters, soon finding himself in the thick of battle. Like the queen's ship, the starfighter began as a

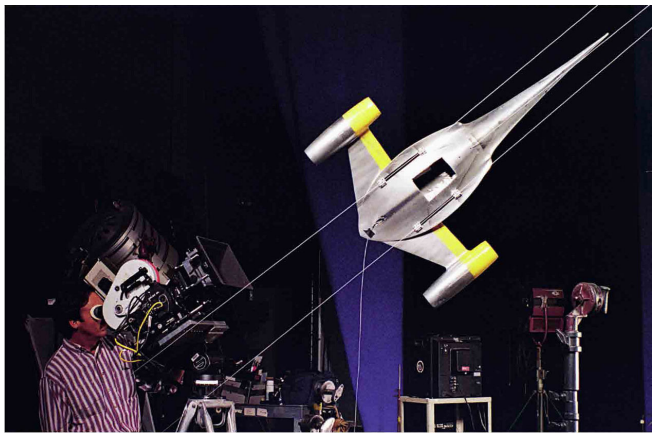
maquette, and was scanned in sections prior to modeling in Alias. Russell Paul surfaced the craft in NURBS while Colie Wertz built wings, engines and cockpit from polygons, with Jonathan Rothbart and Brian La France providing the necessary texturing.

Most of the space battle shots – supervised by John Knoll – began with a motion control battleship element, which established the key-to-fill lighting scheme for the CG ships animated by the rebel unit. “Whatever we did had to look credible,” said Stu Maschwitz, “but how do you define your terms? What level of reality was the right level of reality? No one knows what a real space battle looks like, for instance, but everyone knows what it’s supposed to look like – a motion control model shot. With that in mind, our digital ships were lit by lights that were not placed at infinity – which is certainly available in CG – but instead approximated the distance separating lights from motion control miniatures on our stage. Being able to speak with the guys on stage helped us match the look their work had established in the minds of audiences. If we’ve made it look like models, then we’ve made it look like Star Wars.”

The Naboo starfighters, armed with ineffectual weapons that fail to damage the battleship, come under attack from Federation starfighter droids. Predecessors to the middle trilogy’s Imperial TIE fighters, the starfighter droids – folded compactly for storage – were capable of walking around the battleship hangar bay on articulated appendages, like giant vultures, then transforming into flight configuration. The model shop created two eighteen-inch maquettes, one showing the starfighter droid in horizontal flight mode and the other in upright walking mode. Working from these miniatures, Craig Lyn built a digital model that included the articulations necessary for animators to put the ships into motion in three-craft formations. “The idea was that each group of three worked from the same brain,” stated Maschwitz, “each starfighter performing the same maneuvers, but with a slight offset. Hundreds poured from the battleship launch bays and attacked the Naboo fighters in swarms.”

Instructed to hide in one of the parked starfighters, Anakin finds himself in the thick of battle when he inadvertently takes off in it. To distinguish the ship as its rookie pilot struggles to master the controls, the rebel unit animated an erratic flight pattern for it that was in vivid contrast to the slick maneuvers performed by the other starfighters.

Anakin’s first flight had a clear delineation in style that set him apart from the other, experienced pilots. “We made certain the other ships were performing slick maneuvers,” Maschwitz noted, “flying circles around Anakin, who is barely holding it together.” The rebel unit was tasked with providing embellishments that made each part of the space battle unique. “At the start of this

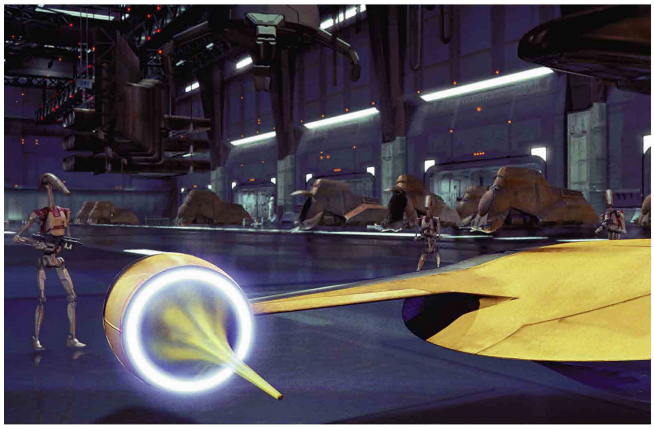


Outdoors, or on stage against black or bluescreen, pyrotechnician Geoff Heron orchestrated a

show, I told my crew to give each shot the kiss of love. Near the end of the work on any given shot, I wanted to be able to sit down with the animator and have him show me some special little signature element – something no one else would notice until the twentieth time the movie is seen."

staggering number of practical explosions for the ground and space battle sequences. Pat Turner sets up a shot of a pyro-rigged starfighter model, mounted on wires. As the high-speed camera rolled, the model would be detonated, then released to travel down the wires, creating a dramatic fiery tail on film.

To accommodate the huge quantity of warring space vessels, a layered approach was taken with the ship animation. This was in keeping with the asteroid chase in The Empire Strikes Back and the space battle that concludes Return of the Jedi, where background elements incorporated various approaches to fill out imagery featuring motion control miniature foregrounds. "In every single shot – even with just a simple story point, such as Anakin's turning and flying away – there were three to four layers of animation," said Maschwitz. "We reserved most of the real hero animation for the plot-point stuff in the foreground, handling that aspect with full-resolution digital models. We had hero background animation, as well – custom-tailored to the shot and hand-animated – that maintained the continuity of action and direction established in previous shots."

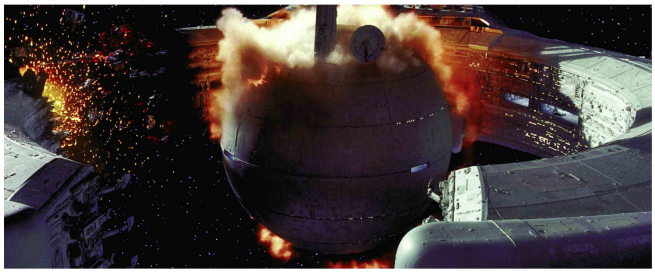


Having penetrated the battleship's defenses and landed his starfighter inside its hangar bay, Anakin fires on some advancing droids and accidentally hits the reactor room of the ship, causing the massive craft to detonate in a series of violent explosions. On a battleship model specially constructed for the destruction scene, Geoff Heron rigged a dozen sequenced blasts to occur within a fifth of a second, as high-speed cameras captured the action.

Behind the foreground imagery would be general mayhem, a maelstrom of activity created largely as particle elements. “We tried flocking solutions,” recalled Maschwitz, “but it was easier to just take the shapes and animate them, building a number of different movements over time into a complex sequence. With a sufficiently large library, the maneuvers become so complex, viewers cannot detect individual motions being cycled. Personally, I’m fascinated by the idea of using simulation technology to get these things to chase each other around automatically; but the concerns of any one shot are not always best addressed by some hyperrealistic simulation. In the case of the space battle, it was usually about ‘we need more going on in this corner.’ We could try forever to get that via simulation, or we could just put the dots in there.”

On-board battle droids flee as the battleship begins to self-destruct.

Live-action cockpit shots featuring Jake Lloyd and the other actors were illuminated by a light attached to a big hoop that could swivel back and forth to simulate the changing angle of the sunlight. “If you look at the previous films,” remarked John Knoll, “they always have the sun moving a little in the cockpit shots. That added some dynamics and created justification for moving the starfield, which gives the shots a lot more energy.” Bluescreen cockpit elements were composited into the digital backgrounds via Saber. Provided with 3D ship geometry produced by the rebel unit, Rita Zimmerman created the impression of glass in the cockpit windows by adding a texture with refractive qualities and scratches. Further Saber enhancements included specific interactive lighting cues to tie background explosions into the live-action foregrounds.



To create a battleship explosion of epic proportions, the 1/800-scale pyro model was filmed at 340 frames per second. Compositors layered in additional pyro elements to expand the scope of the destruction.

Interactivity was also an issue with the rebel unit shots. “Our CG ships flew alongside exploding pyro ships,” Maschwitz said “so we had to incorporate reflections of the explosions in the chrome surfaces of our spaceships. I’d also animate the pilot to look over and react as he jerks and veers away from the blast.” Initially, it was thought that slam-cuts would be needed to transition between digital spacecraft and practical pyro models as foreground ships exploded, but this scenario never developed. “Since there wasn’t a tremendous need for custom fighter ship pyro that matched, we could use the great library of proprietary explosions, sparks and fire

elements built up at ILM over the years. All of that was burned onto CD-ROM for quick access on the background blasts, with custom work utilized mainly for key story points."

Geoff Heron's pyro group had started its work on the movie providing generic blasts to embellish the existing stock. "That was a nice way to ease into the overall shoot," Heron recalled. "Then we got into lots of zero-G exploding stuff for the space battle. Some of the exploding spaceship shots we cheated with respect to gravity. We would put the model in an orientation that seemed to reflect a zero-G position while getting the parts to fall the right way and the fireball reading better in motion." Other models were launched down wires and exploded. "There is something about the trail left in the air of an object blowing up while in motion. The difference is subtle, but when you have a static model with a fan on it to blow the trail back, it just isn't the same. Momentum, gravity and the kind of smoke cloud that keeps going all change. Flame interaction on the surface sometimes changes, as well." Explosions were filmed against bluescreen and greenscreen, as well as against black, depending on the requirements of each cut.

Anakin's starfighter is hit by enemy fire and spirals into the battleship's hangar, plunging through that compartment and continuing deeper into the gargantuan vessel. The sequence of shots required a set of digital extensions, based on blueprints and stills from the practical hangar miniature. The photos were patched onto geometries constructed by Shadi Almassizadeh that conformed to the blueprints, with the various battleship interior compartments derived from these repeated and reconfigured elements for the backgrounds in view during Anakin's wild ride. Other digital models, such as the landers used for the ground invasion, helped fill out the virtual backgrounds, while bulkhead doors separating the ship's internal compartments – elements that were not present in the hangar miniature – had to be painted from scratch.

The shiny deck of the battleship interior needed to reflect the passage of Anakin's starfighter. "We flew a cruciform camera rig, with six cameras mounted on it, through the set," said Maschwitz. "The camera move matched the flight of Anakin's ship, with the cameras providing views that allowed me to render out quick, low-rez environment maps looking up, down, left and right. These maps simulated the general environment of the battleship interior; and this was the only way to get good reflection elements without resorting to ray-tracing."

Anakin brings his craft to a stop within the battleship, only to find battle droids approaching. The boy attempts to dispatch them with torpedoes; but his attack goes wide of the mark, and the streaking projectiles instead strike the battleship's reactor room, setting in motion a series of blasts that climax with the vessel's utter destruction. To achieve the desired effect, Geoff Heron collaborated with the model shop in developing materials that would suggest the essential scale of the conflagration. "Steve Gawley had four people in his shop working on the exploding battleship," Heron elaborated. "They produced blanks out of the mold for undetailed models we could get started on; and we just depth-charged into it, testing a variety of pyro formulas." Early test shots were done in 16mm, with high-speed Vistavision cameras being rented only after the frame rate and pyro issues had been fully resolved. "The battleship was close to 1/800-scale, so we had to run at 340 frames per second to get seventy good frames for the cut. That worked out to a fifth of a second in real-time action for the hero portion of the

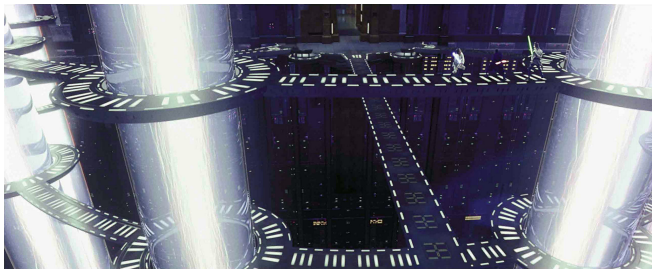
event, with twelve to fifteen sequenced blasts occurring through that short duration. The initial explosions broke the model in key places, others allowed fire to sneak out of the cracks blasted in the miniature, and then the big bombs went off to destroy the whole thing."

Detail views of the destruction often combined Heron's explosion elements with digital modeling of the surface breakup, both of which were tracked onto the practical motion control battleship element. In some instances, mandrels matching the contours of the battleship from the perspective of the motion control camera were used so that the blasts would conform to the battleship's basic shape, as was the situation with the command sphere at its center.

For a climactic lightsaber duel in which Qui-Gon and Obi-Wan engage the evil Darth Maul (Ray Park), Scott Squires' unit was charged with creating miniature and digital environments such as a vast generator room filled with glowing energy tubes, an 'energy corridor' and a pit room with a seemingly bottomless generator core. Modelmaker Grant Imamara at work on the generator room set.

As fighting continues on land and in space, a third battle is also underway – a fight-to-the-death lightsaber duel that pits Qui-Gon and Obi-Wan against Darth Maul in the Theed palace. The Scott Squires unit took on the lightsaber battle, with Steve Molin supervising and Jeff Doran addressing the compositing issues. In the course of the battle, the Jedi knights and Sith villain cross a catwalk spanning a generator room full of glowing energy tubes, descend to a floor-level corridor of opening and closing walls of energy, and end up in a 'pit room' containing a seemingly bottomless generator core. The energy corridor and pit room showcased partial live-action sets with digital extensions built by Jack Haye on a foundation of photographic set references, blueprints and a foamcore production model.

Prop lightsaber blades used during the live-action were rotoscoped, then replaced with the glowing sword effect established in the original Star Wars films.



Throughout the sequence, the actors were shot against bluescreen, surrounded by limited sets, or often no sets at all. Final shots required extensive after-the-fact environment construction, achieved with 3D geometry, digital matte paintings or miniatures, depending on the requirements of each shot.

The battle between the Jedi and Darth Maul was actually the initial assignment handed to the Squires unit, and was designated 'most difficult of the show' by many on the team. Though Doug Chiang's art department had produced detailed drawings and mockups of the setting, there were still many unresolved issues. "There was nothing to pin a look to," recollected Barry Armour. "It was a shot in the dark, an iterative search. 'Energy corridor' for example – what the heck does that look like? We built the environment from scratch, then noodled it until Doug thought it looked right and George liked it."

One of the generator room design issues was the giant glowing tubes and their lighting effect on their surroundings. "We spent a lot of time working on particle systems," said Squires, "coming up with some interesting looks for the energy tubes. I wanted to see silhouettes of the characters, so we played the entire scene with lens flares, obscuring and flashing over them, like an overexposure." That look, though originally approved by Lucas, would be one of the major changes made along the way. "We finished the sequence," recalled Heather Smith, "and then George changed the concept so that it was no longer a blown-out contamination of light affecting everything in the environment. We took off the overall haze so the tubes became more contained and the light didn't affect the entire shot."

For some shots, the combatants were extracted from a live-action set and dropped into a virtual set. Trying to meet a quota of thirty-some setups per day during principal photography, Lucas had filmed on the practical sets quickly and without too much concern for perfect bluescreen setups – which had a tremendous postproduction impact on the ILMrotoscope department. "It

was the famous ‘fix it in post’ situation,” noted Susan Kelly, “but not in a bad way. Our shots could be combinations of extractions, rotoing portions or just straight roto. We ended up rotoing a lot of bluescreen elements. We’d make a matte of the characters and their lightsabers, then hand it off to a compositor who’d place them in the 3D set.” Generating mattes for the lightsaber blades was a major assignment in itself. Roto paint artists Zachary Sherman and Trang Bach articulated the lightsaber shape, then compositors utilized Comptime to complete the shots. “Our compositing program, Comptime, generated the plug-in for the look of the saber. We would animate the matte throughout the shot, pop it in the plug-in, and run it to determine whether it looked good or not.”

Shots of the energy walls visible within the generator room’s energy corridor were created in Saber. “Some of the shots were precomped in the CG department, and Saber would just add the final energy wall,” said Squires. “In a number of cases though, there was no 3D involved; so we’d do the entire shot in Saber.” Ultimately, the Saber department contributed more than fifty shots of the sliding energy walls. “We’d get the precomps – the elements generated in the 3D world – and put the energy walls over that,” commented Saber artist Brian Conlon. “The energy walls themselves consisted of more than thirty-five layers of elements. Each was similar, but would have different aspects, such as speed and color, which were tracked into the scene in 3D space. The corridor floor was reflective, so we also had to match the reflection with the action of each energy wall.”

Although Liam Neeson and Ewan McGregor performed most of the fight themselves, the extremely acrobatic nature of the lightsaber battle had required that stunt doubles be employed for a few shots. “In three shots where the stuntmen’s faces were visible,” noted Squires, “we did face replacements using pieces of footage of the real actors. There is another shot where Darth Maul does a backflip and ends on a higher walkway. In doing it, the stuntman had landed on a thick pad, which we had to remove. His legs were also replaced with digital animated legs.” In addition, fight choreography that might have proved dangerous on the set was simulated by splitting apart the actors in the composite, then positioning them closer to each other.

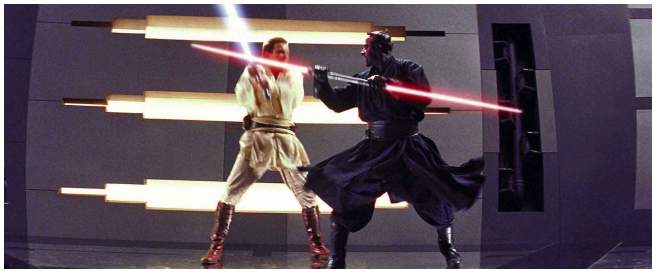
The duel ends in the death of both Darth Maul and Qui-Gon. Darth Maul’s lightsaber demise started on stuntman/actor Ray Park, then transitioned to a CGreplica of him being split in two. In case the rather gruesome death presented problems in getting the movie its desired rating, an alternate, less graphic version of the death was also created in CG.

In his dying moments, Qui-Gon exacts a promise from Obi-Wan to take Anakin under his wing and to train him as a Jedi. What follows is the arrival of Yoda – who bestows his reluctant blessing on Obi-Wan – and a victory parade through the streets of Theed. A shot near the finale of Yoda walking would feature a CG Yoda animated by Hal Hickel. Rob Coleman had actually approached Lucas early on about doing more of the Yoda shots digitally. “I kept reminding him of something I’d read when I was a kid,” Coleman stated. “George was quoted as saying, ‘By the time I get back to doing these movies, you’re going to see Yoda walk.’ I wanted to hold him to that. I really think we’re getting a subtlety into our CG performances that is so good, these characters look real. So we could have done all the Yoda shots, or at least some of them. Maybe next time.”

Lead roto artist Susan Kelly and rotoscopers Trang Bach and Zachary Sherman review a shot from the generator room sequence. In addition to producing mattes and isolating lightsaber blades, the rotoscope department was often engaged to extract the actors from partial live-action sets so they could be deposited into full digital environments.

Qui-Gon and Darth Maul face off in the pit room. Although the fight was shot primarily against bluescreen, interactive lighting was incorporated to suggest illumination from sources within the nonexistent generator room.

For the victorious street celebration, Theed was restored as a place of enchantment by the Squires unit, which conjured up the spectacle of the Gungan army parading beneath the great arch into a palace plaza lined with cheering citizens. The final scene integrated thousands of CG Gungans with bluescreen and digital-video live-action Theedians, a backlot set of the palace steps extended with CG and digital matte paintings, model shop miniatures and flourishes of CG confetti.



His master slain by Darth Maul, Obi-Wan takes up the fight alone.

The Theed victory parade was one of the production's great compositing challenges, due in part to the scene's magic-hour lighting – especially difficult since months, and in some cases years, had separated the live-action elements filmed in England and the miniatures shot at ILM. To integrate the Gungans – who are riding kaadu, waving banners and generally cutting loose with joy – a matchmove plate was prepared in order to provide Rob Coleman's unit a 3D space in which to animate their characters. "Once the animation was approved," said Greg Maloney, "our TDs would take the character models – with all their color maps, bump maps and texture maps, reflections and lighting – and begin setting up the render. We would then take that into the plate and start roughing it in. At the same time, a TD or compositor would begin building the environment from elements consisting of miniatures, CG 3D environments, matte paintings and live-action sets shot in England."

Throughout ILM's involvement, a team of four visual effects editors, headed by Scott Balcerek and David Tanaka, worked to assemble the effects sequences on an Avid nonlinear editing system – a system that enabled Lucas to tweak effects shots up until the time of the film's release. "A couple of years back," recalled Tanaka, "George said that he wanted to be able to tackle a film the way a painter approaches a blank canvas. He'd have his palette and his brush, and he'd be able to touch up every aspect of the painting in any way he wanted. He wanted to deliver digital filmmaking – and in this film, he has. Even something that looks like simple production footage is often not. Take a two-shot with Padmé talking to Anakin, for example. It looks like it's straight production footage – but there are actually six layers making up that one shot. When it's broken down, layer by layer, you realize it's a split between the two characters – Jake Lloyd gave his best performance in take one, but Natalie Portman's best was in take seven. George wanted those combined, which was easy enough – but there's more. When Jake finished his lines, he left his mouth open – but George wanted the mouth closed. So we went into take fifteen to find the best take in which his mouth was closed, and we used only that part of that take. In another moment, Natalie looked at Jake, then looked down – but George wanted her looking down, then up at him – so we threw her plate into reverse motion. But there was steam rising in the background that was now also running in reverse as a result, so that had to be rotoscoped around Natalie to create forward-flowing steam while she was in reverse. That was how these layers piled up – and why the Avid was essential to the editing of this movie."

A side issue of that nonlinear editing was that finals were not necessarily finaled, and shots that had been approved months previously could suddenly be ‘unapproved’ and revised as Lucas developed new ideas. Inevitably, such an approach slowed production – but it was all for the good of the final product. “New ideas were constantly coming up,” Dennis Muren stated, “ways to improve shots, ways to change them for the better. And because of the way this film was being made, we could make all those changes and improvements.”

Creating ever-better shots was what the project was all about for the three effects units – especially since each was attempting to rise to the understandably stratospheric expectations of audiences that had waited sixteen years for this movie. “Way back when we started Empire Strikes Back,” Muren recalled, “I remember thinking, ‘My God, how are we ever going to top Star Wars?’ But the way I handled it then, and the way I handled it this time, was to realize that everybody was going to do the best they could. That’s it. You do that and you try not to do anything that isn’t fresh. There’s not much more than that you can do. Frankly, ninety-nine percent of the people working on this film never felt that pressure to begin with, because they hadn’t worked on any of the previous Star Wars movies. Most of them were hardly born when those films were made. So rather than being stressed, they were just very excited. We all were.”

Not only did The Phantom Menace create excitement among everyone at ILM, it also engendered an almost irresistible sentimentality, especially for those who had been children or young adolescents when the initial trilogy was released. A thirteen-year-old when he first saw Star Wars, Rob Coleman remembered with clarity the profound impact it had on him. “I saw it with my family,” Coleman recalled. “Of course, when you’re thirteen you can’t sit with your folks, so I sat in the row ahead of them. When the movie was over, I immediately turned back to my Dad behind me, and said, ‘I’ve got to see this movie again.’ So he let me hide in the seats in the theater – something he had never let me do before – and I watched the next showing. Afterwards, I walked home alone from the theater – another first. As the years went by, I went to one of the first showings of The Empire Strikes Back, and then Return of the Jedi – by then I had just graduated from high school. After Jedi, I remember returning to my car a little sad, thinking, ‘I wonder if I’m ever going to see another Star Wars movie?’ I wondered how long I would have to wait – having no idea that I would be one of the people who was going to help bring it to the screen.”

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POPULATING PLANETS

ARTICLE BY ESTELLE SHAY

With its epic scope and wondrous worlds teaming with droll, bizarre and colorful characters, Star Wars Episode I: The Phantom Menace was surely the Holy Grail for any makeup effects artist fortunate enough to occupy a niche, however small, in its journey to the screen. No wonder then that Nick Dudman, who headed a team of talented and eager artisans charged with fashioning the film's hordes of practically conceived aliens, had no trouble locating recruits. For Dudman, the project brought back memories of an earlier time when, as a young apprentice directly out of art school, he had worked under the tutelage of veteran makeup and creature designer Stuart Freeborn on The Empire Strikes Back. From that auspicious beginning, Dudman had gone on to other Lucasfilm projects, including Return of the Jedi, Willow and Indiana Jones and the Last Crusade. As a freelance make-up effects supervisor, he would later launch his own company, Pigs Might Fly, under whose banner he would oversee the imaginative creature work on The Fifth Element and The Mummy.

In typical Lucas style, the decision to bring Dudman on board the The Phantom Menace creative team was made with minimal fanfare, as preproduction on the film, based at Leavesden Studios in England, proceeded at full speed in preparation for the June 1997 start of principal photography. "It was December of 1996," Dudman recalled, "and I happened to be at Leavesden consulting on Mor-tal Kombat: Annihilation, when David Brown, The Phantom Menace production manager, came by and said: 'I'm glad you're here. I wanted to chat with you. Can you bring your portfolio next week?' We got together then, and he had Rick McCallum come by. It was bizarre, actually, because they looked at my portfolio – which was pretty straightforward stuff – and Rick just said: 'Yeah. Let's do it.' I stuttered, 'Have I got the job then?' And that was it. I had no idea what was actually involved at that point. I'm not sure that they did either."

In January, with just six months of lead time before principal photography was slated to begin, Dudman flew to Skywalker Ranch to review the art-work and storyboards produced by design director Doug Chiang and his team, as well as root through the existing collection of Star Wars materials preserved within the Lucasfilm archives. Meanwhile, preparations were underway at Leavesden for an on-site creature workshop, furbished to Dudman's precise specifications. "We

literally built the shop from the ground up," said Dudman. "We had a set of offices on the first floor, with a series of bunkers underneath, and when we got there, everything was filthy and covered in dust and cobwebs. So before we could start, the place had to be cleaned out and painted and completely wired and plumbed. But there were many advantages to having us on site. Leavesden had originally been an old aerodrome and airfield, and there was barbed wire fencing all around – which made security easier. Understandably, production wanted the secrecy of the operation totally under their thumb. We were all issued swipe cards; and no one could get into the place without punching in a code. There were alarms all over the place, and we were constantly setting them off – but they were that serious."

By March 1997, a core crew was assembled – many of them having previously worked with Dudman on The Fifth Element. Among the recruits were creature workshop supervisor Chris Barton – who would oversee the animatronics and engineering – chief sculptor Gary Pollard, key bodysuit fabricator Monique Brown, finishing supervisor Michelle Taylor, prosthetic makeup designer Mark Coulier and feature effects coordinator Lyn Nicholson. Other crew members would come aboard as need arose, with the team eventually expanding to include, at its peak, some seventy craftspeople. "We were very organized right from the start," remarked Dudman, "because I was using largely the same people I had used on Fifth Element, and we could sort of leap in without spending a lot of time figuring out who was going to do what. Once I had my key team, we began interviewing others. Everybody in the business wanted to work on this film."

The work would fall neatly into two categories – prime characters and background ones. Of the 146 separate aliens eventually produced, the majority, not surprisingly, comprised the latter category – background characters seen mostly on Tatooine, crowding the streets of Mos Espa or filling the huge grandstands during the podrace. "The background characters were, by and large, ones that we reprised from previous Star Wars films," observed Dudman. "So it was a case of looking at the original designs, and saying: 'Okay. What was in the cantina sequence from the first Star Wars on Tatooine? Who was in Jabba's palace in Jedi?' We also dug through various fan magazines and books to find what all of the characters were called. We pinned the pictures of each of them up on the wall, plus some designs for new ones the Ranch had done. Then we walked around with George and Rick McCallum, and asked them, 'Which ones do you want and how many?' It was all very casual. George noted that he'd always liked the Greedo character from the first film, so we said: 'Fine. How about ten of them?' I mentioned that the Hammerhead from the cantina was one of my favorites, so George said: "Okay. Let's have, say, five of those.' We ended up with lists of these creatures. From there, we determined how many we'd need overall for each sequence."

Frequently a determination on what approach to pursue, or even if a particular creature should be done at all, was based strictly on economic consid-erations. "George had obviously had people doing endless designs, for months and months, at the Ranch," noted Dudman, "and we were sent a lot of them – both for background and prime characters. So we budgeted them all out. 'Okay, that can be an animatronic puppet. This is a multi-piece makeup.' Once they were costed out, the production might come back, and say: 'That's too much. We'll drop these. Can you come up with something else?' Of course, the minute my team realized there was the

slightest chance of design input, they all sort of went crazy, and I had to promise them that I would personally show every single design they came up with to George."

Once the selections were made, the creature shop wasted no time getting started. Most of the background characters involved simple one-size-fits-all foam masks, so the work was not contingent on the casting of specific actors. For those, Dudman relied on a mass-production approach, churning out heads, hands and feet by the dozens with factory efficiency. "The whole crew was busy from day one," commented Dudman. "Nobody ever had to sit around waiting for the next stage of something to come through, because we could say: 'You've got nothing to do? Go sculpt a Squidhead. That's the one we need next. Mold it. Foam it. Start mass-producing it.' With so many background characters required, there was always a huge pile of molds that needed foaming, or unpainted body parts, or things with seams that had to be dealt with."

Racing to complete the background creatures in time for the Tatooine location shoot in Tunisia, Dudman sometimes had to rein in overeager crew members determined to put forth their very best effort and perhaps leave their personal mark on the film. "Things still had to be sculpted with great attention to detail," Dudman observed, "because we knew that all the fans were going to pick them apart based on what went before – but we also had to be practical. It was up to me to say: 'You know, you've been airbrushing that thing for three days – and it's green. We need forty of them and we haven't the time to mess around.'"

Although it was standard procedure to design heads that could be put on and taken off quickly, filming of Tatooine scenes during the two weeks the production was on location in Tunisia was complicated immeasurably by the stifling desert heat. As a cautionary measure, the Dudman team rented cool suits – waistcoats pumped with glycol coolant – which could be worn under creature bodysuits to keep the performers somewhat comfortable. Still, the on-set crew – in particular Mark Coulier, who doubled as alien extras supervisor – had its hands full, looking after the contingent of seventy-five mostly non-English-speaking locals conscripted for the crowd scenes. With temperatures that sometimes soared, incredibly, above 140 degrees Fahrenheit, the logistics of wrangling large numbers of performers in suffocating rubber masks, bodysuits and prosthetics required a carefully orchestrated effort. "We built our own cooling devices – battery-powered rechargeable fans, about six inches square with a long tube on the end," Barton commented, "and had a team of people on the set who'd go up to anyone wearing a head, pop a tube through the mouth or somewhere else, and pump cold air in to clear exhaust gases. It was just easier and cheaper to build our own fans than try to cannibalize or adapt what was commercially available. Each was fitted with a filtration system to keep sand and dirt out. As much as you want cool air when you're hot and sweaty and in a suit, it doesn't feel very good if it's laced with sand."

Health and safety issues were, of course, para-mount. "We had some translators running about, who were constantly scanning the crowd the whole time," Dudman affirmed. "If they saw somebody in costume who was not responding or was holding his head in his hands, looking like he was about to crash – they went in. The assistant directors understood that if one of my crew ran in with a water bottle, we needed to get somebody out – it didn't matter if they were shooting." At the end of each filming day, all of the alien heads were collected, sterilized, and checked for scorpions before being hung on a rack and transferred back to the hotel for

safekeeping. “We had to check everything for scorpions – that was a big thing. During the shoot there was a horrendous sandstorm that wiped out our base camp and destroyed the set. When we went back the next day and started digging in the sand, looking for things that were buried, all the locals told us: ‘Don’t do that. That’s where the scorpions are.’ So we had to be aware of that. Fortunately, we had no problems.”

While Dudman and Barton were occupied on location, Gary Pollard took charge back at the shop, where the work continued unabated. Construction of the hero characters was underway in preparation for several key scenes slated for filming on stage at Leavesden. Those would involve a more elaborate approach than simple masks, since animatronics and lip-sync capability were frequently called for. Still, the creature team was ever mindful of tight production schedules that left little room for error or delays. “The characters couldn’t be too complicated,” Dudman said. “If mechanics were involved, they had to have backup systems built into them in case something broke. Fortunately, Chris Barton is incredibly good at working out practical solutions. He’s the sort of person who pulls a Leatherman out of his pocket for repairs, and says, ‘We have everything we need.’ On a movie like this, that’s exactly what was called for. It had to be quick, it had to be efficient and it had to be simple.”

Although many of the alien characters in The Phantom Menace were computer generated, scores of others – both major and minor – were created for on-set use by Nick Dudman and his creature crew. Most – essentially background extras – required only simple masks and hands. Dudman with his children, Jack and Holly, playing aliens for a Mos Espa street scene.

Much of the hero work revolved around two key scenes – one in the senate chamber at Coruscant, capital of the galactic republic, where a gathering of delegates from throughout the galaxy has convened to debate a trade dispute that threatens to disrupt the peace. The other – also in Coruscant – was a scene in the Jedi temple, where a high council of twelve Jedi masters has assembled to weigh Qui-Gon Jinn’s recommendation that young Anakin Skywalker be trained in the ways of the Force. The senate chamber scene was the first to be addressed, as it was up first on the shooting schedule. Some thirty characters were created for the sequence, in which senate delegates are seen floating on saucer-shaped pods that soar about inside a cavernous rotunda. Realized primarily with suited performers, the makeup effects ranged from multi-piece prosthetics to

A computer animated Watto hovers amongst an assemblage of aliens created by the Dudman team as spectators for the podrace.

whole heads, mechanized for such things as lip-sync, facial movement and eye blinks. Huge animatronic rigs and bodysuits lent the actors a variety of nonhumanoid looks and shapes.

Working from designs by Doug Chiang's department, Dudman and his team named the characters and translated the designs into a variety of bizarre creations – among them Tonbuck Toora,

a thick-coated, bearded creature in an evening gown; the Swokes-Swokes, a big, warty alien that slobbered with abandon; and Horax Ryder,

a twelve-foot-tall being with a huge sail-shaped head. Included in the odd cast of characters were also such familiar ones as the Ree-Yees – goat-like creatures with round fat bodies and triple eye-stalks, seen briefly in Return of the Jedi – and the Aqualish, a spiderhead alien based on a character from the Star Wars cantina sequence. Another nod to the original films was the Twi'lek delegation, with its three representatives based loosely on Bib Fortuna, Jabba the Hutt's lieutenant in Return of the Jedi.

Most recognizable of the reprised characters, however, were the Wookiee delegates and a protocol droid of the same model as C-3PO. Both character depictions were given a considerable leg up via use of the original suits and heads, obtained from the archives at Skywalker Ranch and refurbished by the creature crew. "The Wookiee head, which Stuart Freeborn designed, was actually a variant on the ape heads he had built for 2001: A Space Odyssey," Dudman related. "It was very straightforward. The inside skull had dental acrylic plates on the upper and lower lips that were each attached, by cables, to the opposite jaw; so whenever the performer opened his mouth, the lips were pushed even further apart by these plates. Although the suit was in pretty good condition because it had been used for publicity over the years, the foam on the original Chewbacca head had totally deteriorated. Luckily, the mechanism still worked perfectly."

Second-unit filming of the senate scenes on a bluescreen stage at Leavesden made ample use of in-house talent, with Dudman recruiting as performers numerous members of his own crew – all eager for a shot at screen immortality. "One reason I was quite happy to put my own crew in the movie," Dudman commented, "was that we could lifecast them immediately, have our molds and be off and running – without having to wait for actors to be cast. We used most of the girls in our artworking crew as Greedos – which were little. Mark Coulier played the lead Ree-Yees, and Howard Swindell wore the Tonbuck Toora suit. One of our sculptors, John Coppinger – who sculpted the original Jabba the Hutt for Return of the Jedi – played various roles, including all three of the Wookiees. He did a great Chewbacca impression. He isn't quite as tall as the guy who actually played Chewbacca in the films; but since you couldn't see his legs in the pod, we stood him on a box."

Seventeen-year-old trainee John Fensom, not to be outdone by his teammates, surprised and delighted the crew with his dead-on C-3PO impression. "We had the original costume, in bits and pieces, and we needed someone to try it on to see how it all went together," stated Dudman. "John said, 'Try it on me.' So we put it on him; and suddenly, he went into this whole C-3PO routine – all the movements, the voice, the whole bit. It was uncanny. While the rest of the crew were laughing their heads off, all wanting to have their pictures taken with C-3PO, I

phoned Rick McCallum, and said, ‘Rick, you’ve got to see this!’ He came right over, and went: ‘Oh my God! Yes! Done!’ And John ended up actually doing a scene with Liam Neeson and Ewan McGregor.” For some of the more elaborate getups, Dudman also convinced McCallum to hire several of the character performers who had done creature work on The Fifth Element. “On that show, we had a couple of guys in the Mondoshawan suits who were especally good. Jerome Blake, who was one of them, ended up playing lots of characters.”

To create the illusion of three distinct aliens per planetary delegation, one-of-a-kind characters were filmed once, moved to a new position on the set, altered slightly in appearance – either through a costume or a cosmetic change – and filmed twice more. The Wookiees presented a problem in that regard, since nothing could be done by way of costuming to significantly alter the suited performer. The solution Dudman devised was to imply a Wookiee of advanced age by simply adding gray and white hair to the suit.

Performers in various guises also comprised the twelve-person Jedi council. Using concept art provided by the Ranch, as well as creature designs of their own, the Dudman crew produced an array of elaborate animatronic rigs, heads and prosthetics for characters such as Yarael Poof, an imposing creature with enormous arms and legs, and a head atop a long, slinky neck that snaked around. Built directly into a chair, the alien body rig was worn and operated by Michelle Taylor. Another Jedi, performed by John Coppinger, was the white-haired Oppo Rancisis, a hairy creature that looked a bit like a Pomeranian, with a serpentine torso and tail that curled around his chair. For Ki-Adi-Mundi, actor Silas Carson wore a multi-piece prosthetic makeup, sculpted and applied by Kate Murray, that resembled an elderly human being, but with an outsized head – complete with beard, mustache, contact lenses and teeth – stretched to unusual proportions. A simpler, pull-on mask was designed and sculpted by Howard Swindell for Plo Koon, a creature with grids across his eyes, whose distinguishing accouterment was a breathing respirator. The sole female member of the ensemble had a humanoid form, but with tentacles emanating from her head in place of hair.

Among the council members, a familiar face stood out from all the rest – that of Yoda, the wise, all-knowing Jedi master whose patient schooling of Luke Skywalker in The Empire Strikes Back had first empowered the young Jedi aspirant to tap into the Force. One of the most beloved and memorable figures to emerge from the Star Wars pantheon, Yoda was one character whose return to the screen after a twenty-year absence had to be approached with the utmost of care. While re-creating Yoda – originally conceived and performed as a hand puppet – through purely digital means was clearly an option, the consensus was to avoid the impulse to alter the character in radical ways simply because the technology now existed to do so.

Given the task of creating a new and improved puppet, but one that still retained the essence of its predecessor, Dudman first returned to the archives at Lucasfilm. “We got out all the original molds and pieces,” stated Dudman, “and had them shipped to England. Because I had worked on the first Yoda as Stuart Freeborn’s assistant, I knew what the puppet’s Evolution had been, and what worked and did not work. The original Yoda was a prototype. At the time, nobody knew the tensions or pressures that the mechanisms would be under, or had even the slightest idea what problems would be encountered; so there was an awful lot of repairing that went on – as there would be with any prototype. This time, I had a team of people who’d been building puppets for years, and they knew what to expect. But we were treading a fine line. The original Yoda had certain aspects to him that were idiosyncratic. One of his eyes tended to blink slightly slower than the other, for example. I thought: ‘If we correct all this – which we certainly can do – are we going to kill the character the fans know and love?’ We finally decided to build it very much the way the original was built – but add or improve things where we could.”

Creature crew member Fay De Bremaeker dries foam latex castings for two of the alien creatures.

One player who was clearly indispensable was Frank Oz, the man responsible for Yoda’s voice and charismatic performance. Convinced that there was no way to do the character without Oz’s participation, Rick McCallum had extracted a commitment from Oz – now a film director of note – for a return engagement as Yoda’s primary puppeteer. Even as the creature team undertook construction of the new Yoda, Oz was consulted by Dudman and asked to provide insights into the character. “Frank was the guy who created Yoda,” Dudman asserted. “He wasn’t just a hand up a glove; he was the one who brought Yoda to life – so naturally he was the one to tell us how the character should be played. We talked to him early on and asked what changes he would expect to see in a Yoda that was fifty years younger and in different circumstances.”

Sculpted by Gary Pollard, the new Yoda – with minor exceptions such as having brighter eyes and a bit more hair – remained essentially unchanged, the rationale being that a fifty-year age reduction

would be relatively inconsequential in terms of an eight-hundred-year lifespan. Dudman did, however, opt for several key improvements in construction and mechanical design. “We were aware that there were a lot of things we could do more efficiently,” Dudman noted, “and that we could be very creative with new materials and new technologies. The biggest change was the use of silicone instead of foam rubber for Yoda’s head. Silicone translates movement better than foam does. It’s very fluid and natural, and it blurs mechanical exactness in a very friendly way. Because it has a slight translucency, it also gave Yoda a much healthier, organic look. Of course, it meant a great deal more weight, because silicone is so much heavier than foam.”

To provide Terry Jones and Shane Baron with a physical presence against which to perform, Anice Bell – who was later the model for Jar Jar – wore a Yoda suit and headpiece fashioned by the Dudman team.

Since Oz’s arm would be inside the puppet, bearing the full brunt of the added weight, Chris Barton sought ways to lighten the load. One weight-reduction strategy was to take all of the ten servos that would normally have been installed in Yoda’s head and relocate them to a pack that Frank could wear on his back. “That was something we did when we built the Mangalores for Fifth Element,” Dudman commented. “On that show, we had decided that we didn’t want servos in the head because of all the added noise and weight of batteries, transmitters, receivers and such – plus the fact that they limited our sculpt because we had to allow space for them. So, instead, we had all of the cables coming out of the skull and traveling down to servos on a sliding rack. As a system, it worked very well. In the case of Yoda, it meant that all that weight was on the puppeteer’s back, not at the top of his arm being held above his head.”

Other improvements consisted of eye articulation and ear movements that were radio-controlled rather than cable-operated, radio-controlled brows in place of manually operated ones and a newly added smile mechanism. Mechanical hands were built to alternate with gloved hands worn by Oz and puppeteer Cathy Smee, while mechanical feet alternated with loose ones that could be folded appropriately under Yoda’s cushiony body – fashioned in lycra by Maria Boggi.

On stage at Leavesden, Frank Oz, assisted by his own puppeteers, operated Yoda from beneath the elevated set. Inserting one of his arms through the body and into the head of the puppet, he took the weight of its head on the top of his hand, producing the lip-sync by inserting a thumb into the lower jaw and his fingers into the upper. Head and body movements were controlled by the motion of his arm. Off-camera, Dave Greenaway operated the eyes – as he had done on the original Yoda – while Don Austin controlled the remaining facial articulations. Two video monitors provided the below-deck crew with a window to the activities on the set above – one displaying a wide view of the character, the other enabling the operators to see precisely what the camera was seeing, so that they could react accordingly.

Mirroring Yoda in mechanical design and construction was Yaddel, another member of the Jedi council from the same race as Yoda, albeit much younger. Built as a sort of shadow project concurrent with Yoda, Yaddel was sculpted by Gary Pollard, fabricated by Maria Boggi and mechanized by Josh Lee. “The only distinction between Yaddel and Yoda was in the sculpt,” Dudman commented. “There’s a seven-hundred-year difference in their ages, so Yaddel was made to look younger – a rather effete-looking character with a big swathe of hair.” Operating

from below deck, Philip Eason – primary pup-peteer for the Yaddel character – maneuvered the mouth with one hand and one of the puppet's hands with his other.

Throughout the creature shop's involvement, Dudman found the boundaries between digital and practical effects shifting as production sought to keep a lid on rising costs. "There were certain characters – like Jar Jar and Boss Nass – that had to be brilliant," noted Dudman, "and that meant investing huge chunks of money to carry digital technology further than anyone had ever carried it before. Some of the other characters were less critical. So once costings came in, there was a lot of: 'Hang on there. We thought this character might be CG; but we have to cut some corners. Could this perhaps be an animatronic or a prosthetic makeup?'"

A case in point was the decision to employ a practical rather than digital approach in creating the duplicitous Neimoidians overseeing the Trade Federation assault on Naboo – principally Nute Gunray and Rune Haako. Just twelve weeks before shooting was scheduled to begin, Rick McCallum informed Dudman that a 'rethink' was in order with regard to the characters and that a practical solution would now be needed. Unfortunately, the basic Neimoidian form – designed with CG execution in mind – was not compatible with this notion. "These are the first aliens you see in the movie," Dudman remarked, "and Nute and Rune have an almighty amount of dialogue. We said: 'Okay, we'll do them. But we need to know what they look like.' So George got out this Star Wars Chronicles book, and found a couple of green-headed characters with oblong red eyes in the back of the cantina – they were very much background things – and just went: 'Those are the Neimoidians.'"

In a race against time, Gary Pollard set about expanding on the existing, rather simple concept through a series of maquettes that extrapolated details from the original characters, accentuating their more interesting aspects – an effort that won prompt approval from Lucas. While humanoid in silhouette, the Neimoidians were a distinctive lot whose looks mirrored their sinister natures. "They had a sort of reptilian, slimy quality," said Dudman, "with glowing eyes that had slits through the centers of the eyeballs, no central pupil, and fixed eyelids, but with a membrane that flicks across from underneath. Their mouths were full of jagged, black, rotting teeth. They had long green fingers and wore the most extreme, ornate clothes – which the costume department did a wonderful job on. They were basically horrible civil servants."

Translation of the Neimoidian designs into practical form entailed the construction of animatronic heads and skin-tight painted bodysuits, to be worn by Nute and Rune performers Silas Carson and Jerome Blake. As with Yoda, silicone was employed for the heads to give the characters more realistic, organic movement. To save time, Chris Barton and his mechanical team – principally Steve Wright and Tamzine Hanks – made use of parts cannibalized from the Mangalore heads Dudman had fashioned for The Fifth Element. Operation of the heads functioned in much the same manner as the Mangalore heads, with servos consigned to backpacks worn by the actors so that the constructs would be lighter and easier to move about. Slits in the creatures' eyeballs lined up with the performers' eyes – a deliberate design feature that made it easier to see out.

Facial articulations were radio-controlled from off-camera by Wright and Hanks. Lip-sync was rudimentary as there simply was not time to come up with a more complex, computer controlled system. “The only problem we had with the Neimoidians was that the skins were very tight,” noted Dudman, “which made them hot to wear. But part of the way we work is that we not only have people on set with cold air fans, we also have a team of people who do nothing but run around with cold drinks and cold chamois leathers, looking after the actors and keeping them as cool as possible.” Besides the principal Neimoidians, the creature team also produced a three-person Neimoidian delegation for the senate chambers sequence. With time in short supply, the Nute and Rune actors were recruited as the Neimoidian senators, wearing animatronic heads that assimilated the previously built internal mechanics, but with new features fashioned over the top.

Lead sculptor Gary Pollard at work on a subtly younger Yoda, one of the creature crew’s most demanding assignments.

Jar Jar Binks, one of The Phantom Menace’s most important characters, was another CG design that would benefit from Dudman’s practical ministrations. Essentially humanoid in silhouette, the nearly seven-foot-tall Jar Jar – a comical, bumbling Gungan outcast who befriends Qui-Gon Jinn and Obi-Wan Kenobi early in the movie – had been earmarked from the start for digital realization by Industrial Light & Magic. However, concerned that an all-digital Jar Jar might devour too large a portion of the effects budget, the production initially strove to keep its options open. “We were asked, ‘What would this character look like if we did it as a man in a suit?’” Dudman recalled. “We looked at the designs – which they’d obviously done tons of work on – and said: ‘You can’t put a human being in that. And surely, the whole point of the gag of Jar Jar is that this obviously is not just a person in a suit.’ But they insisted that we try; so we dug a lifecast out, and I said to Gary Pollard: ‘Okay. Try to sculpt this design over a human being, as near as you can, and let’s see from that where we can and cannot go with it.’ Gary did a very clever sculpt that caught the essence of Jar Jar – but, of course, certain things had to be cheated.”

Most of the characters on the Jedi council – including Yoda, who was puppeteered from beneath the set, and Ki-Adi-Mundi, an actor in makeup – were created by the Dudman team.

While the Gungan would ultimately remain an all-digital character, Dudman was tasked with building a practical suit and headpiece for Jar Jar vocal performer Ahmed Best, who would stand in for the CG character on set and create a live performance so that the other actors

would be able to play off something real. “Gary Pollard sculpted a full-size Jar Jar head and shoulders,” stated Chris Barton, “which we molded in fiberglass and cast in foam rubber and mounted atop a special cap that Ahmed wore. There was a gauze visor that he could see through, but that hid his eyes from the other actors; so rather than looking eye-level at him, they were forced to look up at the creature.”

Along with the head, Best wore a lycra-covered Jar Jar bodysuit fabricated by Monique Brown from a lifecast, with built-in muscles and pull-on arms and feet. Sewn into the neck was a series of green, light-emitting diodes designed to provide ILM with registration keys to aid in matching up any CG they might want to overlay onto the real actor for mid-range or long-distance shots. While only one foam head was built, the creature team provided three body suits and scores of replaceable Jar Jar arms and feet. A full-size silicone head was also created and mounted on a C-stand so it could be wheeled onto the set whenever lighting reference was required for one of the ILM plate shots.

Having produced practical creatures for a film destined to be known for its unprecedented utilization of digital characters, Nick Dudman reflected on the importance of balancing contributions such as those provided by his team against the ultra-real computer animated effects audiences have come to expect. He recalled a moment, toward the end of the shoot, when George Lucas had approached him and confessed that having seen what ILM was proving possible with Jar Jar, he was now convinced that digital character animation would soon replace lip-syncing animatronics. “I said, ‘I agree,’” Dudman recollected. “‘We can’t compete with that, because we’re limited by the laws of physics, momentum and gravity.’ But then George added: ‘I think prosthetic makeups of the kind we’ve done here, however, will go on forever, because these characters cost a fraction of what it would cost to do them digitally. At the end of the day, Jar Jar will have cost us what we would have paid for a major-league star. Given his importance in the movie, that was a sound investment. But when you think of all those other characters that were in this movie – you wouldn’t for one minute consider paying that kind of salary.’ And I thought that was very perspicacious of him. Jar Jar will bring people into theaters, so he’s worth the investment. But if you’re dealing with characters where that kind of investment is not so critical, why spend millions when you can get by with tens of thousands?”

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